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Contents for June, 1938

AIRPLANES FOR POPULAR FLYING . . . . . *Alexander Klemin* 463
OPTICAL PROJECTION . . . . . *H. F. Kurtz* 469
SHARE-WAGES . . . . . *Olin Ingraham* 474
BOILER OPERATION AS IT AFFECTS PRIME MOVERS . . *S. E. Tray* 475
HOW USEFUL IS YOUR SENSE OF PROPORTION? . . *W. E. Johnson* 481
WELDING APPLIED TO PLANT MAINTENANCE AND REPAIRS . *H. R. Wass* 485
IMPORTANCE OF MAINTENANCE TO FOUNDRY OPERATION *W. C. Bliss* 489
THE TECHNIQUE OF USING LANTERN SLIDES . . . . *S. M. Tucker* 491

EDITORIAL 461
BRIEFING THE RECORD 492
LETTERS AND COMMENT 501
A.S.M.E. BOILER CODE 503
BOOK REVIEWS 509
A.S.M.E. NEWS 510

INDEX TO ADVERTISERS 36

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New 42-Passenger Douglas DC-4 Airliner Under Construction

(Showing installation of engines and retractable nose wheel of tricycle landing gear)

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No. 6

MECHANICAL ENGINEERING

JUNE
1938

GEORGE A. STETSON, *Editor*

Missourians Protest

TO LOYAL Missourians old and young who were pained and shocked to read in the April issue of MECHANICAL ENGINEERING that the custom of observing St. Patrick's Day as a significant holiday for engineering students was alleged to have originated at Minnesota, public acknowledgment of letters of protest and presentation of Missouri's claims is hereby made. The April story has uncovered a wealth of material relating to this annual spring festival which is being cherished for publication at a later date. Perhaps we have something here—a collection of legends, folklore, gests, and sagas to keep alive the glories of engineering in the past, and the origins of its traditions.

What Is Engineering?

UNDER the title "Engineering: What It Is and Does," The Engineering Public Relations Committee, London, has issued a small pamphlet as one of a group of projects whose object is to familiarize the public with engineering matters. Fifteen professional engineering institutions, of which the Institution of Mechanical Engineers is one, are cooperating with the committee and were concerned with its formation. The pamphlet, illustrated with excellent reproductions of photographs showing engineering work and structures, describes briefly the evolution of engineering, its services to mankind, and its reliance on research, and advertises the availability of lecturers for schools and colleges. Within the limitations of its size, the pamphlet does an excellent job of painting a broad picture which, if it does no more, should open the eyes of laymen, particularly parents and boys, to "what engineering is and does."

Back of any organized attempt to give publicity to the nature and accomplishments of engineering lie many motives. There is the natural and selfish desire on the part of engineers to enhance their economic status and to secure public recognition of the fact that engineering is a profession. Some expressions of this desire can be interpreted as attempts to place restrictions on entry into the profession for no higher motives than those of self-preservation—the ideal of the "closed shop," with legal safeguards against competition and overcrowding. On the other hand a genuine concern for the maintenance of high standards that will insure the greatest public good and result in a continuation of achievements of a constantly increasing degree of excellence motivates another, and, we like to think, a more representative, group. Recognition of the fact that the security and progress of modern society depend more and more on technology and applied science gives concern to thoughtful men who realize that the best talent and highest competence are demanded of those engaged in engineering work. Recruitment becomes a problem of prime importance, and endeavors are made to give boys and their parents reliable information and advice on engineering as a career. Restriction is viewed in terms of the elimination of waste in education and human effort; "propaganda" as a means of attracting those most likely to succeed.

The further civilization advances, the greater are the demands made on engineers. The more widespread civilization becomes, the sharper grow the spurs of competition. The successes of engineers are highly valued by the militaristic nations, but in the peaceful achievement of security and a high standard of living these services would yield a richer harvest. Whether it be aggression or the more abundant life men seek they must look to engineers for accomplishment, and hence it is necessary that the public be instructed as to what engineering is and what it does.

Engineering Foundation Reports

CURRENT researches being carried on under grants of money by the Engineering Foundation on projects sponsored by the Founder Societies are summarized in the recently issued report of the Foundation for the year ended Sept. 30, 1937.

Projects in which The American Society of Mechanical Engineers has an interest include studies of cutting fluids, carried on under the direction of O. W. Boston, of the University of Michigan; experiments with the critical-pressure steam boiler at Purdue University, under A. A. Potter; fluid-meters research sponsored by a committee of which R. J. S. Pigott is chairman; test runs on a surface-fatigue-testing machine developed by Earle Buckingham, at M.I.T., for the committee on strength of gear teeth, R. E. Flanders, chairman; continuation of the work of the joint committee on the effect of temperature on the properties of metals, H. J. French, chairman; and program planning by the reorganized committee on lubrication, G. B. Karelitz, chairman.

Persons familiar with the expense of research will wonder how the Engineering Foundation can assist not

only the A.S.M.E. projects mentioned, but many others sponsored by the Civils, Miners, and Electricals, the University of California, the E.C.P.D., and the Personnel Research Federation when its available income during the year covered by the report was only $37,000. The answer to this question is to be found in the way in which the Foundation operates. The grants it makes are, in scientific parlance, catalysts; they make possible the collection of additional funds raised from a variety of sources as contributions to specific projects. This the report makes clear. Capital funds having a book value of $961,000, from the original and subsequent gifts of the late Ambrose Swasey, Henry R. Towne, Edward D. Adams, Seeley W. Mudd, Central Hudson Gas & Electric Corp., W. S. Barstow, H. d'B. Parsons, Alfred D. Flinn, and others, constitute the financial framework of the research structure reared by the Foundation and provide means for originating, organizing, financing, and following through cooperative projects of broad interest to the engineering profession and benefit to the public.

Obviously, with a larger endowment, the Foundation could increase the amount and value of its work. In addition to Mr. Swasey's munificent gifts, and those of others the E. H. McHenry bequest, which is in the hands of executors during the life of two beneficiaries, and which was appraised at the probate of the will, in 1931, at approximately $400,000, is the only important contribution that has yet been made to the Foundation's capital funds. It is hoped that the excellent work of the Foundation, going forward with new zeal under the directorship of Otis E. Hovey, member, A.S.M.E., will attract the support it deserves in the form of further contributions in substantial amounts from patrons of engineering research. Mr. Swasey's inspiring vision in making possible a foundation that bears not his name but that of the profession he so brilliantly served provides an example to others who may wish to acknowledge the debt that they owe to research and engineering.

A.E.C. Conducts a Forum

THE FIRST of a series of forums to be conducted under the recently adopted policy of the American Engineering Council took place at Philadelphia, May 13, at a time when all but this page of the present issue had been made up, and hence a comprehensive account of the excellent papers and discussions cannot be reported at this time.

As an organization composed of groups rather than persons as members, the American Engineering Council is one step further removed from the individual engineer than is the Society or club through which his official connection with the Council is maintained. Although perhaps 60,000 engineers enjoy this connection with A.E.C., less than one hundred actually attend annual meetings of the Council and its assembly. However, were individual memberships held, and did attendance at annual meetings of the Council bear the same ratio to total membership that it does in national society meetings, possibly ten or fifteen thousand engineers would assemble annually at Washington. So stupendous a gathering would have its drawbacks, but one of its good features would be the opportunity to make clear what the Council is and what it attempts to do. It would also stimulate enthusiasm for the Council's work. Hence, decision to hold a series of forums throughout the country marks another significant phase of the Council's history.

The forum at Philadelphia did bring the American Engineering Council directly and personally to the notice of about 200 engineers. The general subject, "Employment and the Engineer's Relation to It," was developed in five scheduled addresses, and discussion thereon, which commenced at luncheon and extended until after ten o'clock with a short recess before dinner. The presiding officers, W. L. Batt, past-president, A.S.M.E., at the luncheon session, and William McClellan, president, A.E.C., at dinner, were sufficient guarantee that the forum would be vigorous, realistic, and stimulating. Ably supporting this leadership were experts from the fields of industry, economics, and finance who provided the solid substance that held the audience beyond the limits of time that a person experienced in the wearying effect of long discussion on nonengineering subjects would customarily set. The attention and enthusiasm displayed by the audience, therefore, constituted a tribute to the value of the matter under discussion.

Following an explanation of the plan and purpose of the forum, by Frederick A. Allner, chairman of the A.E.C. Public Affairs Committee, Dr. Leo Wollman, of Columbia University, spoke on labor policy and prospects for employment, ably supplemented by Ralph E. Flanders, past-president, A.S.M.E. The industrialist's point of view on the contributions of technology to employment was presented by Leonard J. Fletcher, of the Caterpillar Tractor Company, and cleared the way for a discussion that had to be adjourned in order to provide opportunity to reset the tables for dinner.

After dinner, William J. Kelly, president, Machinery and Allied Products Institute, introduced the important but complex subject of the relation of technology to finance, to be followed by Stephen DuBrul, economist, General Motors Corporation, who switched to the more familiar ground of technology and competition. As Mr. Kelly was compelled to leave before discussion of his paper could be begun, it was fortunate that he was able to designate so competent a substitute as George H. Houston, president of the Baldwin Locomotive Works, member, A.S.M.E., to defend his thesis. Too much credit cannot be given Dr. McClellan for his wise and thoughtful comments and his final summing up of the results of the forum.

Certainly the success of the forum was sufficiently pronounced to warrant the holding of another at some other engineering center where the American Engineering Council can demonstrate to engineers what it stands for and how it is attempting to fulfill its destiny.

AIRPLANES *for* POPULAR FLYING

By ALEXANDER KLEMIN

NEW YORK UNIVERSITY

THE QUESTION is frequently asked: "Is popular flying close at hand?" By this is meant not the flying undertaken in large and expensive aerial yachts that Long Island sportsmen purchase from time to time, piloted by professional fliers, housed in special hangars with cranes to swing them into the water, and maintained by expert mechanics. It means flying with machines of low price, requiring minimum hangar space, piloted by an owner of purely amateur standing, and serviced with about the same degree of attention, or lack of attention, which is given to the family car.

THE LOW-PRICED AIRPLANE

It is impossible to answer this question categorically, but there are many favorable factors in the situation. In the last few years many small low-priced airplanes, Taylor Cub, Aeronca, Porterfield, and others, have been sold, and this year perhaps three to four thousand have been disposed of. In 1938, unless the present recession persists, a great many more small airplanes will be sold. College flying clubs wage an annual contest for the Loening Trophy. A number of clubs are located, in different parts of the country where young men of modest means together purchase one or two of these small machines, learn to fly at ridiculously low cost, and thereafter enjoy the pleasures and thrills of the most modern of sports. The ideal airplane "flivver" is not yet here, but perfectly good two-seater airplanes are available, which, with an engine of about 40 hp, land at a speed of under 40 mph, reach a maximum speed of 85 to 100 mph, have splendid flying qualities, are equipped with all the essential instruments, are good for a cross-country flight of two or three hours' duration, have a mileage of 25 to the gallon, and do not cost more than $1300 to $1500. Their price will, of course, decrease as more people learn to fly, and mass-production methods become possible.

Fig. 1 shows a typical light plane, the Taylorcraft, equipped with a 40-hp, four-cylinder opposed, air-cooled Continental engine and mounted on twin Edo floats. Owing to the substitution of floats for the landing gear, the gross weight is 1130 lb. The useful load of 426 lb allows for pilot and passenger, 10 gal of gas, 1 gal of oil, and 18 lb of baggage. It speaks well for the efficiency of these small aircraft that take-off from the water takes only 30 seconds.

A particularly noteworthy feature is the water rudder placed at the rear end of the float which improves handling qualities in the water. The high-wing monoplane is braced with two struts on either side which come together at a single point at the fuselage.

FIG. 1 TYPICAL LIGHT PLANE MOUNTED ON TWIN FLOATS

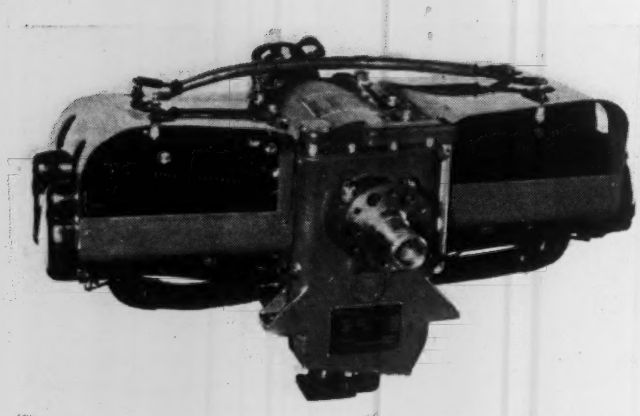
ENGINES FOR LIGHT PLANES

The success of these light planes is due in no small measure to the dependability and efficiency of the small aircraft engines now available. Originally, these were built with standard automobile or motorcycle parts in an endeavor to secure low prices. Continuous full-throttle operation in the air of such engines led to many difficulties not encountered in ground vehicles and a rapid evolutionary process took place.[1] Exhaust-valve material was changed to the nonburning type, crankcases were found to need heat-treated alloys of good fatigue resistance, and better forgings were used for crankshafts. In general, automotive parts were eliminated, and practice now approximates that of the splendid large aircraft engines, though single ignition and the minimum of accessories have remained and certain parts are still much less finished than in the *Hornets* and *Cyclones* of the air liners where expense is almost no object. In spite of their simplicity, the low-power engines remain rather heavy and, even though their power has been increased to 50 hp in the latest offerings, such as those of Lycoming, Menasco, Continental, and other builders, their weight of 155 to 165 lb gives a much higher weight-power ratio than is available with more powerful aircraft engines. Compression ratios are somewhat lower and fuel consumption per brake horsepower-hour correspondingly higher.

Fig. 2 is a front view of the new Franklin 50-hp engine which is typical of the latest practice. It will be noted that, even for these light engines, a

Presented at a meeting of the Bridgeport Section, Bridgeport, Conn., April 15, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[1] "Engines for Light Airplanes," by N. N. Tilley, *S.A.E. Journal*, April, 1938, p. 28.



Courtesy of Scientific American

FIG. 2 FRONT VIEW OF THE NEW FRANKLIN 50-HP ENGINE WITH "TUNNEL" COWLING

"tunnel" cowling is provided to minimize head resistance and give better cooling for the two rear cylinders.

THE MORE AMBITIOUS PRIVATE PLANE

The low-priced airplanes are comfortable and serviceable and with their low loading per square foot of wing area are really safer in many ways than the larger and faster craft. But of course they have not the finish, instrumentation, and all-metal construction of the much more expensive cabin airplanes in the next category, where motors of 90 to 150 hp are employed and occupants may be three or four in number. In the course of this short article, it is impossible to describe the several fine designs available in this class, such as the Fairchilds and Wacos, but a brief description of the representative Ryan S-C will give a fair idea of the general type. The Ryan S-C also includes a number of rather unique details.

Performance is of course much higher than in the low-power class, and with pilot, two passengers, 55 lb of baggage, and fuel for a range of 500 miles, at most economical cruising speed, top speed is 150 mph with a Warner *Scarab* engine of 145 hp at 2050 rpm. Wing span is $37\frac{1}{2}$ ft, wing area is 202 sq ft, and gross weight is 2150 lb. As compared with the light planes we note in particular the following refinements or improvements:

1 Use of a split flap to reduce landing speed and landing run.

2 More complete equipment and instrumentation, in the way of lighting, radio, and other useful accessories.

3 Full cantilever wing construction making for greater aerodynamic efficiency.

4 Use of a trailing-edge elevator tab for trimming purposes.

5 Practically all-metal construction, with a full monocoque-type fuselage of high-strength aluminum with Alclad covering, a stressed-skin wing construction in which the center of gravity coincides with the center of pressure (a valuable precaution against flutter).

Mechanical engineers will be interested in the Ryan as exemplifying the tendency in aircraft construction to use simpler and fewer structural elements and to adopt drop hammers and large hydraulic presses in lieu of the handicraft methods that used to characterize the industry but a few years ago.

Nothing can give as vivid an idea of the excellent modern design and many new ideas being evolved as a series of photographs. Fig. 3 shows the wonderful vision obtainable with the Plexiglass hatch and windshield, and inverted Menasco engine, which may be substituted for the Warner radial. Transparent plastic materials have this tremendous advantage over glass, of allowing compound curvatures and the finest aerodynamic forms. In Fig. 4, we can see that the advantages of the venturi cowling are now available in planes far smaller than the air liners. The comfort of the modern enclosed but well-ventilated cabin is enhanced by the sliding hatch which avoids the difficulty of opening doors against the propeller blast and makes exit or entry easy. Entrance to the cabin is by a walkway along the wing next to the fuselage.

The modern automobile has borrowed much from the airplane, but the converse is also true. Thus in Fig. 5, we see that the designer has borrowed from automobile practice by providing a hinged hood cowling which gives easy access to the engine for inspection and overhaul. It will be readily agreed that American aircraft has gone a long way from the drafty, open cockpits, slow and logy planes, with Christmas-tree external bracing of the early days.

NOVEL IDEAS

The widely advertised $700 flivver plane proudly announced by the Bureau of Air Commerce did harm to the industry and its sales by arousing hopes in the public mind which were never realized. But the publicizing of the plane and the subsequent design competition, though in noway interrupting the steady evolutionary process of private-plane design, did arouse much discussion of several novel ideas, such as the tricycle landing gear, the limited revival of the pusher, and attempts at "two-control" systems which means the elimination of either the rudder or the ailerons in the control of the airplane.

Before discussing the tricycle landing gear and the two-control system of operation, it may be of interest to examine briefly a few of the machines embodying these novel ideas. Thus in Fig. 6 we see the Hammond Y, which has appeared in more refined form as the Stearman-Hammond constructed on the West Coast. In the Hammond Y a pusher propeller is employed, with engine and propeller disposed at the rear of the nacelle. The tail surfaces are supported at the ends of two

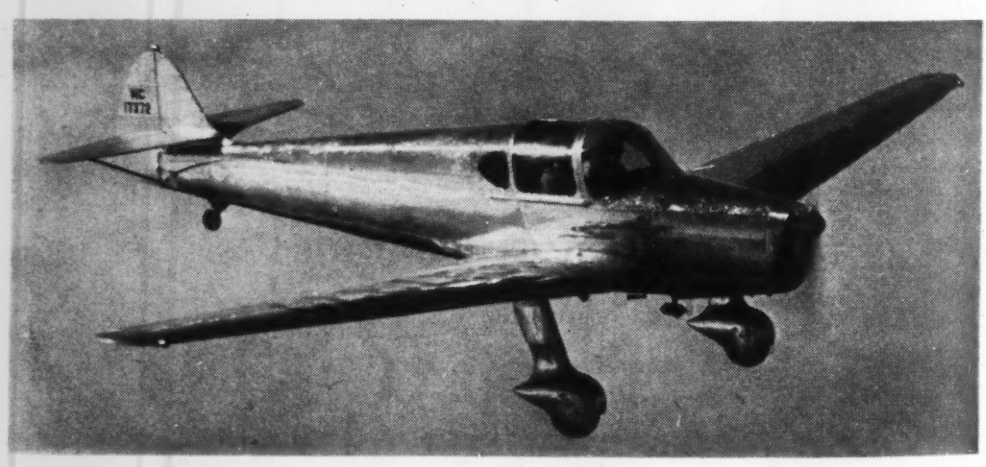


FIG. 3 RYAN S-C AIRPLANE WITH INVERTED MENASCO ENGINE AND PLEXIGLASS WINDSHIELD

long booms, attached to the rear portion of the wings on either side. This machine also embodies the tricycle landing gear in which the two main wheels are placed in back of the center of gravity, and a "nose" wheel is located ahead of the fuselage. We shall discuss the "tricycle" landing gear a little later. But it is interesting to set down the arguments for and against a pusher propeller. In its favor are claimed (*a*) perfect vision ahead, (*b*) no slip stream to bother the passengers, (*c*) less noise in the cabin, and (*d*) no exhaust or oil fumes in the cabin. The contrary arguments are (*a*) lessened efficiency and slower speed, (*b*) difficulty in cooling the engine, and (*c*) the dread of an engine located in back of the occupants. The pusher-vs-tractor controversy is somewhat like the front engine vs. rear engine in the automobile world, and the question will only be settled by long service experience. In some Hammond models, the rudder is dispensed with.

The Waterman Arrowplane constitutes a still more radical departure from the conventional. Here also, we have a pusher with nose wheel, or more properly two nose wheels, but the booms and tail surfaces have disappeared. The wings are swept back with their outer edges slightly turned up to secure longitudinal stability. The ailerons may be used simultaneously as elevators or differentially as ailerons. Instead of the conventional rudder, simple drag elements are located at the tips of the wings. For the "tailless" type that has been assayed many times both in Europe and the United States, greater simplicity and cheapness of construction are claimed by elimination of fuselage and tail surfaces. But the claims have never been substantiated by service use.

Finally, the Gwinn Aircar, Fig. 7, is a biplane in which large stagger is used to delay the stall point of the wings, and the rudder is eliminated, with reliance placed solely on elevators and ailerons for control. Here, we see the tricycle landing gear successfully applied in a tractor machine. The machine has been flown satisfactorily, but its two-control feature is subject to debate as we shall show presently. Having noted briefly the general appearance of these novel light planes, we shall pass on to the more technical discussion of the new ideas.

THE TRICYCLE LANDING GEAR

The first and perhaps the most promising of these new ideas is the tricycle landing gear. The upper half of Fig. 8 shows the conventional and tricycle landing gears in schematic form. On each of these sketches, the position of the center of gravity of the airplane has been indicated. In the conventional landing gear, it is just a trifle behind the main, or front, wheels, and a tail wheel is located at the end of the fuselage. In the tricycle landing gear, a nose wheel is located ahead of the front end of the fuselage and far ahead of the center of gravity, and the two main wheels are just a trifle behind the center of gravity.

Considerable skill is required to land a machine provided with the conventional landing gear. The pilot brings in his machine on a glide and must flatten out just before touching the ground, with all three wheels touching the ground at the same time. Such a maneuver is known as a three-point landing. If he does not flatten out correctly from the glide, and the front wheels touch first, the machine is apt to go over on its nose, particularly if the wheel brakes are strongly applied. The sketch at the lower left corner of Fig. 8 illustrates this highly unpleasant "nosing over."

With the tricycle landing gear, on the other hand, while it is better to make a tail-low landing after flattening out, it is also perfectly possible to land straight from a moderate glide. When the front wheel strikes the ground, the center of gravity is so far behind the wheel, as shown in the lower right corner of Fig. 8, that the machine simply drops down on the main wheels, and no nosing over is to be feared. Certainly this safeguard against nosing over is a great help for the inexperienced pilot.

AVOIDING THE GROUND LOOP

It is conceivable, however, that sufficient safeguard against nosing over might be provided with the conventional landing gear, but there is another reason why the tricycle gear has be-

FIG. 4 ACCESS TO THE CABIN IS FACILITATED BY A SLIDING HATCH

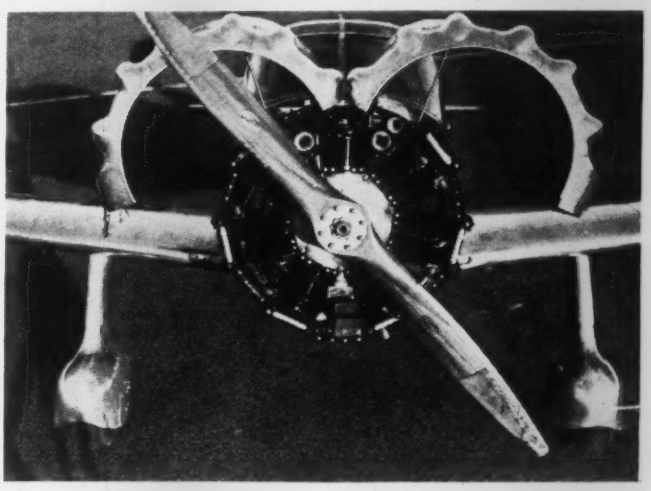


FIG. 5 AN AUTOMOBILE HINGED-TYPE COWL ON A CABIN MONOPLANE

come so popular that it is even being employed on a giant four-engined Douglas transport now nearing completion. This reason lies in the elimination of a hazardous condition known as "ground looping." Suppose the airplane with conventional gear is landing in a side wind from the left, as illustrated in the upper left corner of Fig. 9. The motion of the airplane is not in the direction of its nose, since it is drifting with the side wind. The front wheels have a sidewise motion relative to the ground and accordingly experience a side force from the right. As the wheels are ahead of the center of gravity, the side force turns the airplane away still more from its original direction of motion. This turning and the air striking the machine from the right raise the right wing and wheel off the ground. The airplane turns faster, and the right wheel rises

farther from the ground until the left wing tip digs into the ground. The machine then turns over on its back. This phenomenon of ground looping is not dangerous, but it is ignominious. A pilot who has executed a ground loop unwillingly is not apt to suffer physical injury, but the amusement of onlookers is a serious blow to his self-esteem.

Tricycle landing gear makes the phenomenon of ground looping in a side-wind landing unlikely. The front or nose wheel is mounted on a fork, something like the fork of a tricycle, and is free to turn. The sketch in the upper right corner of Fig. 9 shows what happens with this type of undercarriage in a drift landing with the airplane coming in from the left. Side force on the main wheels is now behind the center of gravity and so tends to turn the machine into the original line of motion. The nose wheel also swivels into the line of motion and helps to steer the machine into the original direction. Therefore, the airplane is soon headed correctly, and all side forces on the wheels disappear. The possibility of a ground loop is definitely eliminated.

There are some drawbacks to the use of the nose wheel, such as shimmying of the nose wheel, for example. Nevertheless, it is now generally admitted that the tricycle landing gear is a step forward in airplane design. It has been adopted not only on the Stearman-Hammond, the Waterman, and the Gwinn Aircar, but also on the more conventional Waco and on the giant four-engined Douglas now nearing completion. The same favorable view of two-control operation is not held by the industry.

The airplane moves in three dimensions. It was the Wright Brothers who took full cognizance of the fact and recognized for the first time in aeronautic history that independent controls about all three axes of the airplane had to be provided. The Wright Brothers, in other words, were the first men in pioneer aviation to provide (*a*) an elevator to provide control in pitching, (*b*) a rudder to provide control in turning, and (*c*) ailerons to provide control in rolling or banking. It was partly due to their understanding of this fundamental theory that they achieved success, and, since their day, three independent controls about three axes have been provided in practically every airplane ever built.

Now, a new school of thought has sprung up with the following proposition. The hardest thing for a novice pilot to learn is the coordination of hands and feet when his hands are controlling the elevator and ailerons through the stick, and his feet are controlling the rudder through the rudder bar. Why not eliminate the rudder altogether and make the task of the novice ever so much simpler? He will then have only elevator and ailerons to think about, and there will be no difficult coordination of hands and feet to bother him.

Let us see how a turn can be made with such a two-control machine, which dispenses with the rudder. Suppose the pilot wants to turn to the right. He pushes his stick to the right, bringing the ailerons into play, and lowers the right wing tip. The machine then sideslips to the right. The side wind strikes the vertical tail surfaces from the right, and, therefore, the machine turns to the right. It sounds simple, but, as a matter of fact, the theory of two-control operation is a complex matter.

The arguments pro and con may be summarized rather briefly. Those in favor of the two-control system urge that:

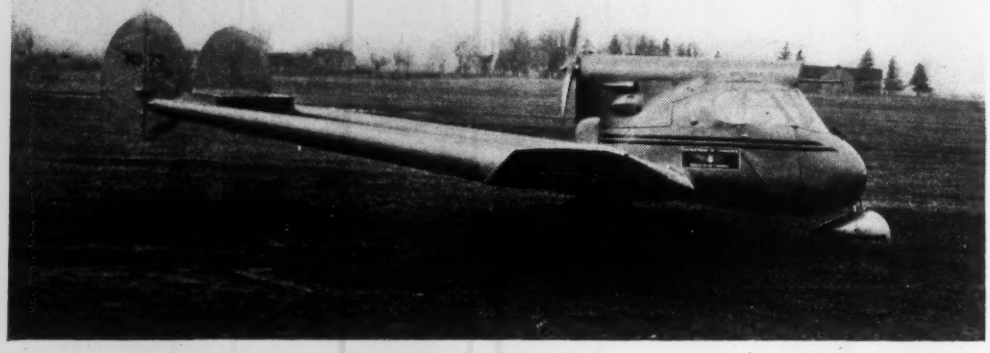


FIG. 6 THE HAMMOND Y AIRPLANE

(This design is equipped with a nose wheel and a pusher propeller which is located at the rear of the nacelle.)

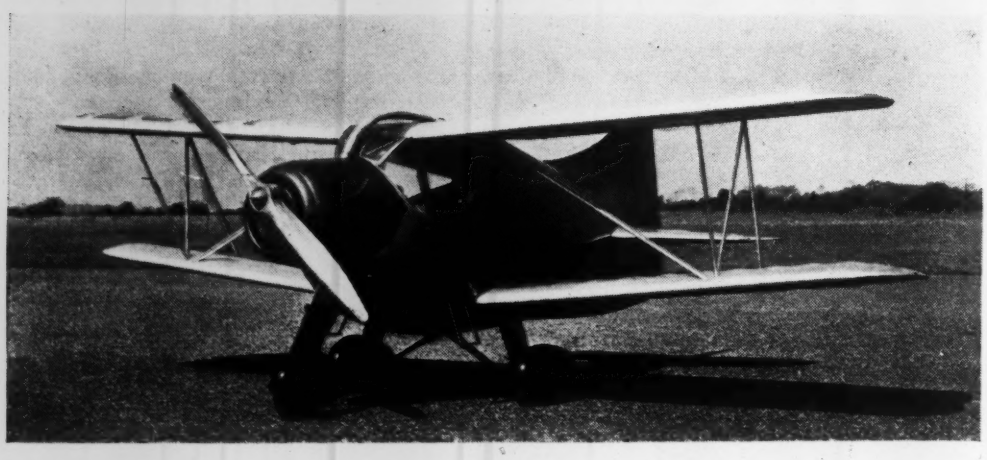


FIG. 7 GWINN AIRCAR

(An interesting feature of this machine is the application of the tricycle landing gear to a tractor airplane.)

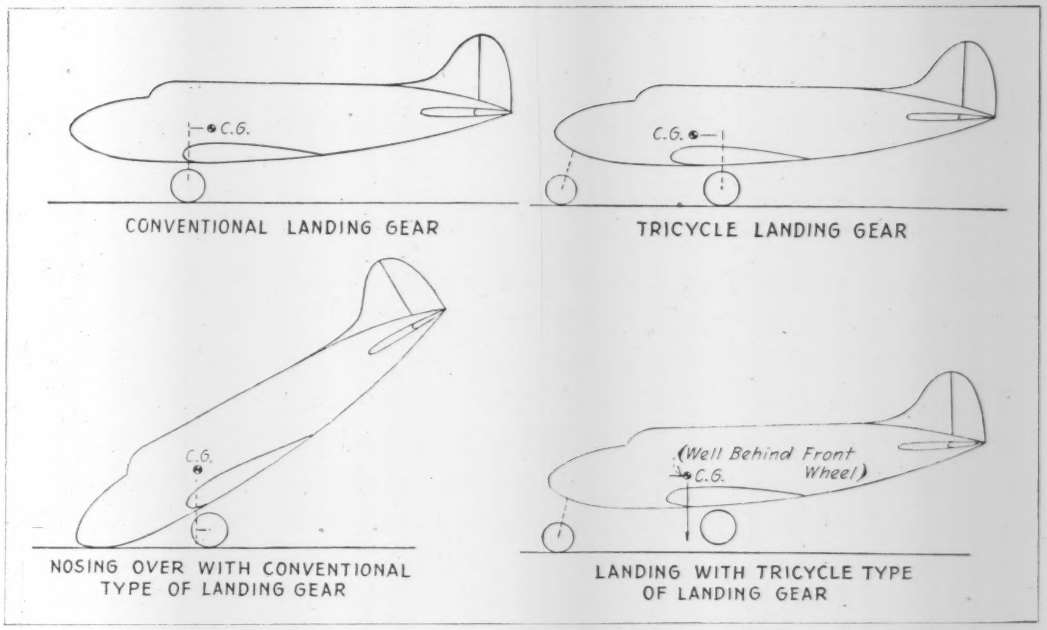


FIG. 8 COMPARISON OF CONVENTIONAL AND TRICYCLE LANDING GEARS

(In the upper pair of sketches the position of the center of gravity is indicated for the conventional (left) and the tricycle (right) landing gear. Nosing over with the conventional landing gear is shown at the lower left. The sketch at the lower right shows how the tricycle landing gear eliminates this trouble.)

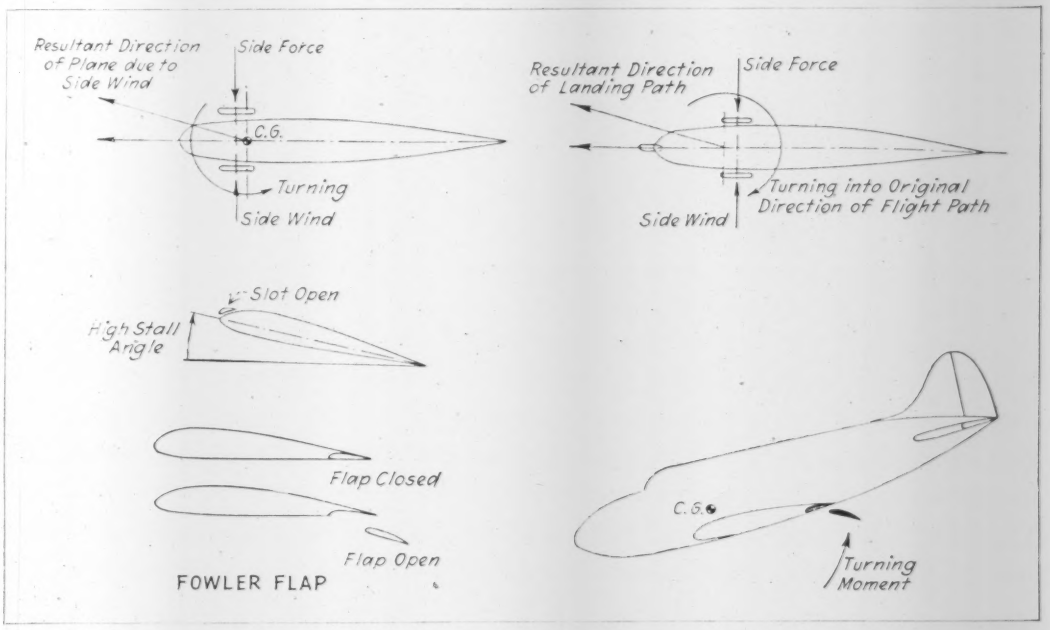


FIG. 9 AVOIDING GROUND LOOPS, STALLS, AND SPINS

(The pair of sketches at the top show side-wind landings with the conventional landing gear (left) and the tricycle type (right) and illustrate how the latter eliminates ground looping. A wing with leading-edge slots which is designed to prevent stalling is shown in the middle sketch at the left. The sketch at the lower left shows the Fowler flap that is intended to make the gliding descent both steeper and slower, and the one at the lower right illustrates the tendency of the airplane to nose down when the flap is moved backward.)

1 The novice has less to learn.

2 Having only two controls to bother about, he is less likely to make serious mistakes.

3 The difficult coordination of hands and feet is avoided.

Its opponents contend that:

1 With two controls, gentle turns and ordinary flying can well be undertaken, but conditions arise in flying when the pilot needs not only elevator, ailerons, and rudder but also wishes that he had some fourth emergency control.

2 With only two controls, it is much more difficult to correct the effects of gusts and other disturbances.

3 With only two controls available, some sideslipping always occurs, and the making or coming out of a turn is never as perfect nor as elegant as with three controls.

4 It is not so hard to use both hands and feet in coordination. After all, does not the driver of a car manage to use both hands and feet with ease?

The argument is never likely to be settled by theorizing. We must wait and see how the new machines built on the two-control principle, such as the Stearman-Hammond, the Waterman, and the Gwinn Aircar behave in actual service.

The author's opinion is that the two-control system may be adequate in normal flying but that it may prove dangerous in an emergency, as when the engine quits suddenly on a steep take-off. The guess is that, eventually, private airplanes will be built which will normally be flown on the two-control principle but will have a rudder available for emergency use. Practical pilots generally oppose the elimination of the rudder; theorists and designers like the idea.

Another important advance in the private airplane is the avoidance of stalling, which means bringing up the nose to so high an angle that the machine stalls and loses lift. The backward motion of the stick may be limited to prevent stalling. Also, wings that do not lose lift for some degrees beyond the

stalling point and wings with leading-edge slots are available, the latter being shown in the middle sketch on the left side in Fig. 9. Both serve the same purpose. If stalling is prevented, the likelihood of the dreaded spinning nose dive, which has been responsible for so many bad accidents, is less. The design of nonstallable, nonspinning machines is already achieved in the theory of the art, and the practical realization of this safety measure is almost a matter of course.

An important element in private flying is the provision of flaps or air brakes that make the gliding descent both steeper and slower. Even with the flaps or air brakes now available, landings are still a little too fast and take-offs a little too difficult. Fortunately, a new type of flap, known as the Fowler flap, is now coming to the front, in which the flap moves back as well as down, so that an actual increase in the area of the wing occurs when the Fowler flap, which is shown in the lower left corner of Fig. 9, is put to work. The Fowler flap is, therefore, more powerful in its action than any flap heretofore employed. It has been employed successfully on a large transport, the Lockheed 14. A number of technical difficulties must be overcome in the use of the Fowler flap, such as the tendency to nose the airplane down when the flap is moved backward as illustrated by the sketch in the lower right corner. But these will be rapidly overcome, and, when the Fowler flap is made available to the private flier, he will be able to land or take off in smaller fields.

THE ROADABLE AIRPLANE

Still another development is in the offing which is of extraordinary interest. As early as 1912 or 1913, a Frenchman named Rene Tampier built an airplane that had two engines, one for driving the propeller and the other for driving a ground or automobile transmission. His machine flew well, and, then, he astounded the citizens of Paris by driving his airplane backward through the streets. This idea of roadable aircraft has been revived in recent years. In the roadable autogiro built by the Pitcairn Company, Fig. 10, the blades are folded back at the airport. The propeller is declutched from the engine and held fixed in position. A ground transmission gear is clutched in and the roadable autogiro proceeds comfortably and at a fair rate of speed along the ground. The Waterman Arrowmobile has achieved the same end, but in this case the wings are taken off the machine before the vehicle can be used along the road. The Arrowmobile is a further development of the Waterman Arrowplane previously mentioned.

It is apparently possible to build an airplane that will be a satisfactory airplane and can be converted into something like an ordinary automobile. Of course, added weights and complications have to be met. The roadable airplane is neither as good as an ordinary airplane nor as good as an ordinary automobile.

With the advent of the tricycle landing gear, the passengers sit in a horizontal position when taxying over the ground and during the take-off and landing run. Making use of this advantage, the designers of the modern private planes have endeavored and succeeded in giving the interior arrangement of their cabins all the comfort and much of the appearance of a modern automobile. It is easy to get in and out. Climbing onto a wing or hanging onto a strut is avoided. The instruments, lighting, vision, seating, and the like are so near to automobile practice that any driver of a motorcar feels perfectly at home inside the new-fashioned airplane. Thus, transition from driving an automobile to piloting an airplane is made as imperceptible as possible.

WHAT OF THE FUTURE?

Now let us try to predict what the near future, say the next five years, is likely to bring us in the way of popular airplanes. It may appear dangerous to make predictions, but, in reality, it is perfectly safe, because nobody ever remembers what a particular person has predicted a few years back.

These predictions are

1 Within five years, at least 10,000 small airplanes for private use will be built and sold to the public every year.

2 The price of these private airplanes, fully equipped, and built of metal or plastic materials, will be no higher than that of the low-priced automobile of today.

3 With the use of the Fowler flap and similar devices, it will be possible to get in and out of the smallest field, so that emergency landings will lose all their terror, and any old lot of ground will be available to the private owner as an airport.

4 Two controls will be used for normal purposes, so learning to fly will be somewhat easier, though the rudder will remain for emergencies.

5 With the nose wheel fully adopted, the dangers of nosing over or ground looping will also disappear and flying technique will again be simplified.

6 With these improvements and simplifications of controls and other operations, it will be as easy to learn to fly as it is to learn to drive an automobile.

7 It is even possible that many purchasers of private airplanes will find available to them a vehicle which they can use either as an airplane or an automobile, just as today they can convert an open roadster into a comfortable closed car.

FIG. 10 THE PITCAIRN ROADABLE AUTOGIRO

(After this machine lands, the blades are folded back, the propeller is declutched from the engine and fixed in position, a ground transmission gear is clutched in, and the machine travels along the ground at a fair rate of speed, being driven through the rear wheel.)

OPTICAL PROJECTION

Possibilities and Limitations in Industry

By H. F. KURTZ

BAUSCH & LOMB OPTICAL CO., ROCHESTER, N. Y

OPTICAL instruments have been used in an ever-increasing number of applications by astronomers, surveyors, navigators, biologists, physicists, military engineers, and many others of the world's workers during the last century and a half. They found their way into the shop and engineering laboratory, however, only twenty years ago or so. There are now available, however, quite a variety of instruments devised by the optician with the help of the engineer for use both in the engineering laboratory and the shop. Among these are microscopes, called shop or toolmaker's microscopes, fitted with micrometer cross-slide stages for measuring small dimensions; inspection microscopes; angle-measuring devices to supplant the sine bar and the ordinary protractor; large measuring machines using the principles of optics for measuring distances and reading scales; tool-adjusting instruments; and many others. The ordinary biological microscope has been widely applied for inspection and adjustment purposes.

Soon after optical instruments found their earliest applications in the shop and inspection departments, projection apparatus made its appearance in the form of the ordinary stereopticon lantern. Its introduction seems to have been inspired by need for a means for the rapid examination of screw threads. This ordinary stereopticon, designed as it was for the projection of pictures, left much to be desired, principally in the way of accuracy of delineation and of ease of manipulation. It was also found that the use of projection apparatus had distinct advantages over the use of other instruments equipped with eyepieces. When an image is projected, it may be viewed by several observers simultaneously and comfortably with both eyes, while the use of the eyepiece type of instrument is restricted to one observer who is forced to hold his head in a fixed and often uncomfortable position and to peer through a small eye lens with one eye only. Further, use of the projection device is not limited to screw threads, but it can be used to great advantage for almost all other parts and tools made and used in the shop.

The optician was then required to develop projection apparatus suitable for this special purpose, and, since that day, some twenty years ago, the specialized apparatus has undergone constant development and improvement. In this discussion, it is proposed to consider what the possibilities and limitations of the most modern optical projection apparatus are.

The purpose of this specialized projection apparatus is to form a magnified image of an object on a conveniently placed screen so that the image can be measured or compared with a standard outline. This image may be thought of as a cross-section plane of the object in the form of a shadow outline rendered at a scale equal to the magnification. The ideal image for the purpose should meet the following conditions: (*a*) It should be geometrically identical with the cross section of the object to be projected; (*b*) the scale of projection or magnification should be precise, or at least precisely known; (*c*) this magnification should be identical for all parts of the object and image; and (*d*) the delineation, that is, the sharpness of the margin of the image, should be sufficiently good to permit the determination of the boundary of the image with a degree of precision exceeding the means provided for its measurement or comparison.

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OPTICAL SYSTEMS FOR USE IN PROJECTION

The diagram in Fig. 1 shows schematically the basic ideal optical system for the purpose. Light from the light source passes through the condensing lens, the function of which is to cause the light to proceed in a bundle of parallel rays, over the object to the projection objective. The object is placed at such a distance from the objective that a sharp image of it is formed on the screen. All of the rays passing parallel to each other in the space between the condensing and projection lenses, pass through a point after penetrating the projection lens. This point lies in the back focal point of the projection objective. In the diagram, only the two marginal rays are shown penetrating the projection objective for the sake of simplicity.

This diagram is ideally schematic. For the image on the screen to be a true cross section of the object, it is necessary that the light passing over it be in the form of a bundle of parallel rays as shown. The object will then intercept a bundle of these rays which is identical in cross section with that of the object, and the objective will then render that cross section in the form of a shadow on the screen. That the beam of light passing over the object may be truly parallel as shown, the source of light would need to be infinitesimal in size. When the light source is finite in size, the light passing over the object will not meet this ideal requirement of complete parallelism of rays, but the rays will be divergent in passing from the condensing lens to the projection objective. The rays increase in divergence or departure from parallelism as the size of the source increases and as it approaches the condensing lens, that is, as the condenser decreases in focal length. This divergent light passing over the object illuminates planes above and below the one that it is desired to project, and, consequently if the divergence is great, the image will be surrounded by a halo. Further, it is difficult to select the plane to be projected and, unless the object is thin and approaches a plane in thickness, a satisfactory image is not possible with a light source of large size.

Naturally, since no infinitesimal source of light, such as is required for ideal conditions of imagery, exists, the task of the designer is to find a source of light which is so small that the effect of its size on the image is negligibly small; that is, the effect is smaller in magnitude than the limiting accuracy of the measuring facilities with which the projector is provided. All known light sources of sufficient intrinsic intensity are too large to meet the requirements, so that recourse must be taken to the expedient shown in Fig. 2. A diaphragm placed in the back focal point of the objective forces the rays of light

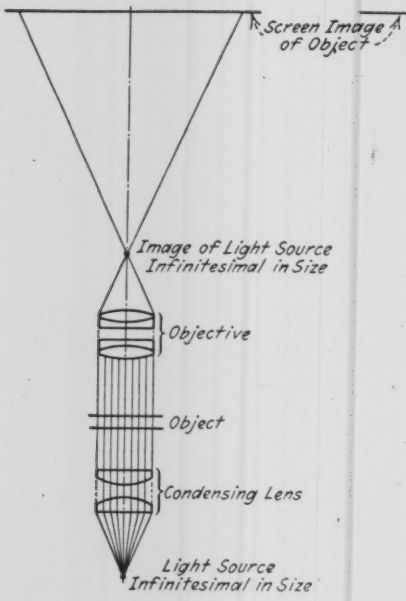

Fig. 1

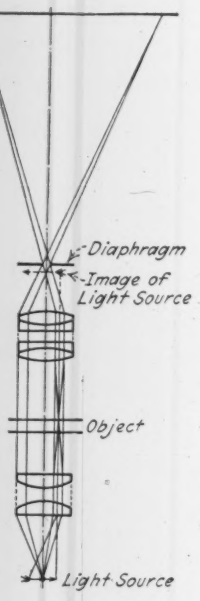

Fig. 2

FIG. 1 IDEAL PROJECTION SYSTEM

(The light source is infinitesimal in size, all rays between the condensing lens and projection objective are parallel to the optical axis and to each other, and the rays, after passing the objective, pass through a geometrical point in the back focus of the objective.)

FIG. 2 PROJECTION SYSTEM THAT APPROACHES THE IDEAL AS CLOSELY AS POSSIBLE

(A diaphragm, which is placed in the back focal point of the projection objective, forces the light passing between the condenser and the projection lens to be confined in small-diameter pencils that are parallel to the optical axis. The rays comprising these pencils diverge only slightly. This system, using a source of finite dimensions, permits the minimum error in magnification when focusing is inexact, forces accurate alignment of the entire system, and prevents halo around the image.)

passing over the object to be confined within small bundles of light, each bundle parallel to the optical axis, and each bundle composed of rays of only small divergence. It will be recalled that this back focal point is the point through which all of the rays pass in the ideal system of Fig. 1.

This diaphragm has exactly the same effect as reducing the size of the light source. In fact, it actually cuts the light source down in effective size, in so far as the optical system is concerned. The light from the marginal parts of the source falls on the diaphragm and never reaches the screen as a part of the image. It is possible, with this diaphragm, to reduce the effective size of the light source in this manner to such an extent that the little remaining divergence of the rays comprising a bundle has no observable effect on the illumination of planes above and below the plane to be projected. A diaphragm such as this in the back focal plane of the objective should be a part of every contour-projector optical system because it has three beneficial effects which are (*a*) only light of small divergence is permitted to participate in the formation of the image, and, therefore, the formation of a halo around a thick object is prevented; (*b*) only so-called telecentric pencils of light participate in the formation of the image; and (*c*) the diaphragm can be accurately placed on the optical axis.

The second advantage means that only narrow bundles of light, the rays of which diverge slightly, enter into the formation of the image and these bundles are all parallel to the optical axis with the result that the effect of poor focusing of the image is a minimum on the magnification. Without such a diaphragm, the size of the image changes rapidly as the object approaches or recedes from the projection lens, while, with the diaphragm, the magnification changes slowly. In a well-designed optical system of this kind, the image will remain constant in size throughout the range of useful sharpness.

All of the light that reaches the screen must pass through the diaphragm, and an image of the light source is formed in its plane. This means that, if the screen is to be illuminated to the maximum, the image of the light source must fall in the aperture of the diaphragm. It follows, in turn, that the light source must lie accurately on the optical axis and all of the light is forced to travel through the optical system symmetrically and parallel to the optical axis, a condition that must always be met for the best performance of a projection system. Therefore, mere attainment of maximum brightness of the screen is a criterion for centering the light source.

Two penalties are imposed by the use of this diaphragm. First, if it suppresses the marginal parts of the light source, the brightness of the image on the screen is reduced and, second, if the diaphragm aperture is smaller than a certain limit, the image becomes "woolly" due to diffraction. This means, of course, that, after all, if we could secure our ideal infinitesimal light source, it would be useless, because the image would be totally destroyed by diffraction.

This diffraction effect is a function of the linear diameter of the image of the light source in the rear of the objective or of the diameter of the diaphragm if it is smaller than the image of the light source. It, therefore, becomes necessary to use a diaphragm of the smallest dimensions possible which will not materially affect the crispness of the image because of diffraction. Experience has shown that apertures smaller than 2.0 mm in diameter do materially affect the image quality. This means that the image of the light source or the diaphragm restricting it should not be smaller than 2.0 mm for the highest power to be used, because this image becomes smaller as the power increases. The highest power objective used with the apparatus with which the tests discussed here were made is 100×, and the ratio of the focal length of the condenser chosen is such that the image of the light source just fills the diaphragm aperture which is actually made a little over 2.0 mm. None of the light passing through the condenser lenses and the projection objective is suppressed by the diaphragm then, and the screen brightness is the maximum for the light source used. The lower powers used also have diaphragms that will just completely pass the image of the light source. Angular divergence of the light passing over the object is, therefore, a constant for all powers and is the minimum consistent with the avoidance of excessive diffraction effects at the highest power proposed. The halo around a thick object is then the minimum that is consistent with the maintenance of definition or crispness in the image.

The light source used in these tests is the S_1 Sun Lamp made by the General Electric Company, modified for the purpose. Actual size of the radiating element is about eight millimeters. The intensity and character of this source are such that more light can be imposed upon the screen than with any source hitherto available with the exception of the carbon arc, which is decidedly a nuisance in practical application.

Fig. 3 shows the actual path of the light through the system used. It will be seen that the initial direction of the light passing from the source through the condensers is horizontal. The purpose of the lower small reflector is to cause the parallel light after leaving the condenser to travel vertically upward,

so that objects may be placed on a horizontal table, the condition for optimum convenience in manipulating the object. The roof prism and two large reflectors at the right have a twofold function, (*a*) to change the direction of the path of the light to force the image to be formed on a vertical translucent screen above and near the object and (*b*) to cause an erect image of the object to be formed on the screen. The observer then is in a convenient position for critical examination of the screen and simultaneous manipulation of the object. This arrangement causes the image to have the same aspect and directions of movement that the object has when viewed from above.

RESULTS OF PROJECTION TESTS

That we may see to what extent the image meets the ideal requirements set up in the early part of this paper, the following tables give records of data taken and tabulated in such a way as to disclose departures from the conditions. Table 1 presents the results of 10 successive settings of one margin of an image with a fiducial line on the screen. The object was moved across the field until coincidence with the line was judged to be complete, after which the position of the stage carrying the object was read on a gage capable of reading position to 0.0001 in. Ten successive readings were taken on two objects, one 0.015 in. thick and the other 1 in. thick, at each of four different magnifications.

Spread between readings and frequency of departures from zero may be taken as a measure of the accuracy with which an image margin may be set to coincidence with a line. This test checks whether or not the effect of diffraction on the delineation or sharpness is sufficiently small to permit measurements with a degree of accuracy comparable with the limiting accuracy of the measuring device provided. It will be seen that, for a thin object, this accuracy may be taken as ±0.0001 in. for all powers. For the thick object the limiting accuracy may be assumed to be 0.0002 in. for the 10×, and 0.0001 in. for the higher powers.

On first consideration, it might be thought that increase in power should increase the accuracy with which this setting could be made. But further consideration brings one to the conclusion that the margin of an image can be no sharper than absolutely sharp, and, even if this condition were obtained, some error would still be present, due to inability of the eye to distinguish the condition of perfect coincidence. Now, the

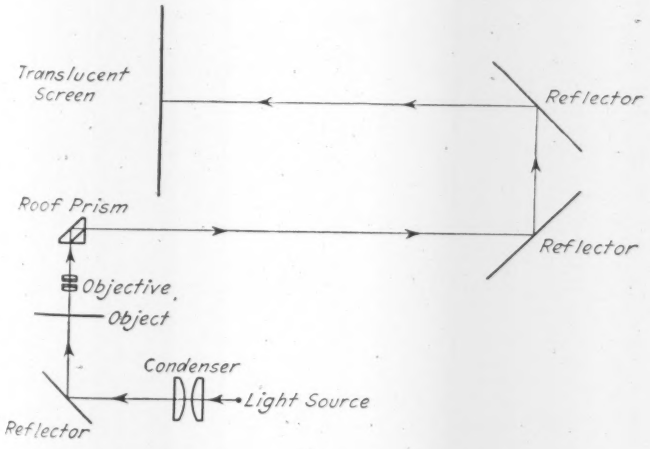

FIG. 3 PATH OF LIGHT TO THE PROJECTOR

(The three reflectors and the roof prism permit the specimen to be placed on a horizontal table and an erect image to be formed on a translucent screen near the observer.)

TABLE 1 COINCIDENCE OF LINE AND IMAGE

Thickness of object, in.							
0.015				1.000			
Magnification				Magnification			
10	25	50	100	10	25	50	100
0	0	0	0	0	0	0	0
+.0001	0	+.0001	0	+.0001	+.0001	0	+.0001
+.0001	−.0001	0	0	−.0002	+.0001	0	+.0001
0	−.0001	+.0001	−.0001	0	+.0001	+.0001	−.0001
+.0001	0	0	+.0001	−.0002	0	0	−.0001
−.0002	+.0001	0	+.0001	−.0001	0	+.0001	−.0001
0	+.0001	0	−.0001	+.0002	−.0001	+.0001	0
−.0001	+.0001	−.0001	0	0	−.0002	+.0001	0
+.0001	0	0	0	+.0002	0	0	0
−.0001	0	+.0001	0	0	0	+.0001	−.0001

TABLE 2 VARIATION IN MAGNIFICATION OVER FIELDS

Magnification	Calculated size of object, in.	Size of image, mm	Measured size of object, in.	Error	
				In.	Per cent
10	0.2010	51.1	0.2011	+0.0001	+0.05
10	0.7500	190.5	0.7500	0.0000	0
10	1.37515	350.5	1.3780	+0.0028	+0.2
25	0.0699	44.4	0.0699	0.0000	0
25	0.25035	159.1	0.25055	+0.0002	0.1
25	0.50005	318.1	0.5009	+0.0009	0.2
50	0.0400	50.8	0.4000	0.0000	0
50	0.1495	190.0	0.1496	+0.0001	+0.1
50	0.28115	357.15	0.2812	+0.0001	+0.04
100	0.0160	40.6	0.015985	0.0000	0
100	0.0699	177.7	0.06996	+0.00006	0.1
100	0.1495	380.5	0.1498	+0.0003	0.2

images formed by the low powers are actually sharper at the boundary than for the higher powers, because the diffraction is less. It was stated previously that woolliness due to diffraction increases as the diaphragm aperture decreases. Since we strive to keep the angle of divergence of the rays within a pencil to the upper limit required to prevent halo and this angle is a constant, this diaphragm is larger for lower powers than for the higher, because the focal length of the low-power lenses is greater than for the high powers. Also, the screen brightness is greater, a factor that enhances the contrast and, therefore, makes the setting of the coincidence easier. Conversely then, as the power increases, the crispness and contrast of the image decrease. It can be seen, therefore, that these effects counterbalance the greater sensitivity provided by greater magnification, to the end that a coincidence between an image margin and a fiducial line is to a large extent independent of magnification and that the limit of this sensitivity is of the order of 0.0001 in. for projection systems that are properly designed to meet other requirements for accuracy.

Table 2 is a record of data taken to show to what extent the other two conditions are met, namely, the accuracy to which the stated nominal magnification and the variation in magnification in various parts of the field can be met. It should be said that the nominal stated magnification for any one part of the field, say the center, can be adjusted by varying slightly the distance between the lens and the screen, and that it can be adjusted as accurately as variation in the image size can be detected in practical usage. A well-established fact in optical practice is that the limit of accuracy to which magnification may be measured by known methods is of the order of 0.1 per cent. That is, repeated measurements taken by several skilled observers cannot be expected to agree to any higher accuracy. Nominal magnification cannot be adjusted to an accuracy greater than 0.1 per cent, and, if data should be found to disclose adjustment or performance to this limit, the apparatus must be considered to be performing to the limit of accuracy possible of attainment by known methods. Elimination of

variations in magnification across the field can be accomplished only by the skill of the lens designer. The author has measured the variation in magnification in many lenses designed for this purpose and of those heretofore mentioned, and none showed a variation of less than 0.4 per cent between the center and margin of a field of about 25 deg in extent, and many of them showed variation of 0.75 and 1 per cent.

In taking the data presented in Table 2, magnification for the smallest-size specimen was adjusted carefully to the nominal rated value and the median and marginal magnifications were measured as accurately as painstaking observation and measurement would permit. The data given are the means of several accurate measurements. To eliminate possibility of unconscious "hunching," objects whose size had been accurately measured by other means in inches were used, and the sizes of the images were measured in millimeters and then converted to inches. The magnification is, of course, the ratio of the size of the image to that of the object. Data are given, however, in terms of the sizes of the images in the various parts of the fields divided by the nominal stated magnification as adjusted for the smallest object. The results are, therefore, represented as the errors in tenths of thousandths of an inch and in percentage of size, incident upon assuming that the magnification is constantly equal to the stated nominal magnification for the whole field. Inspection of these data show that the variation in magnification over the field is in no case in excess of 0.2 per cent. This is a decided improvement over what has been hitherto available in optical systems.

OPTICAL PROJECTION AS A MEANS OF COMPARISON

The advantages of optical projection are applied by two general methods; (*a*) as a comparator; that is, by comparing the image with an outline drawn on the screen; and (*b*) as a measuring device; that is, by bringing the margins of the image successively to coincidence with a fiducial line on the screen and with auxiliary measuring apparatus, usually incorporated in the workholder of the projector, determining the displacement of the object necessary to bring about these two coincidences.

The first of these requires the establishment on the screen of a standard outline made at a scale equal to that of the magnification due to the projection. This outline, of course, should correspond to the cross section to be projected. It may be made in one of three ways: (*a*) By a skillful draftsman; (*b*) an accurate standard specimen, if available, can be placed in the projector and its image traced on the screen; and (*c*) the image of the accurate standard specimen can be formed on the screen, after which a photographic negative is made for use as a standard comparison outline.

The first method must, of course, be resorted to when no data as to the form and size of the object exist other than the specifications and drawings for it. The method is susceptible to all three of the errors that were previously mentioned; namely, the limiting accuracy with which the image may be made to coincide with the outline, errors due to the mean magnification and those due to differences in magnification in different parts of the screen in addition to the draftsman's errors, and errors due to poor focusing and centering of the light source which tend to increase the errors of magnification and coincidence. It is safe to say that a careful draftsman can draw to an accuracy of 0.01 in. as a limit. The data presented in Table 2 for a carefully adjusted light source and a carefully focused image indicate a possible projection error of 0.2 per cent for the margins of an image. This means that errors of the order of 0.002 in. may be expected for large objects at 10× and of 0.001 in. or less for the higher powers. For small objects, the error will be less for objects covering one third of the field or less.

If the image of an accurate standard specimen is focused on the screen, the outline may be traced with a sharp-pointed hard pencil. It is certain that a little practice permits tracing such an outline to an accuracy of 0.01 in. The image of the specimen to be measured is, of course, compared with this traced outline. This method is entirely independent of errors either of rated magnification or of differences in magnification over the field. It is susceptible, of course, to errors in determining the coincidence between the image and the outline. The ultimate result should, therefore, in no case be greater than 0.02 in. divided by the magnification and probably of the order of 0.01 in. divided by the magnification. That is, for a magnification of 50×, the error should not be greater than 0.0005 in. Actual practice by skilled operators shows that this value may be bettered by careful work and that the same accuracy may be achieved at lower magnifications, due to lessened diffraction and increased contrast, while it cannot be bettered by increasing the magnification because of increased diffraction and lessened contrast.

Astronomers state that a properly handled photographic plate suffers disturbances of not more than 1 part in 40,000 due to developing, fixing, drying, and other processes when they are carefully and slowly executed. A 10-in. outline on the plate should, therefore, be similar to the image to within 0.00025 in. This third method is again independent of errors of mean magnification and magnification differences over the field but is susceptible to errors in determining the coincidence of image with outline. For a magnification of 50×, the expected error should, therefore, be of the order of between 0.0005 and 0.00025 in.

CONTOUR PROJECTOR USED AS A MEASURING DEVICE

The second application of the contour projector, namely, measuring the amount of motion of the object which is required to bring opposite margins of the image to coincidence with a fiducial line on the screen is also completely independent of errors in mean magnification and of lack of uniform magnification over the field. A further advantage, peculiar to optical systems, is that, since a beam of light is imponderable, no deformation of the object takes place because of the application of points or anvils. Objects considerably larger than the field of the instrument can also be measured. It is susceptible to errors in the determination of coincidence between the margins of the image and the fiducial line and to errors in the measuring mechanism used to determine the positions of the object. Errors due to the measuring mechanism are indeterminable because of the entry of factors of wear, abuse, and the like, but it should be easy to make a mechanism that can be depended upon to 0.0001 in. It should be possible, therefore, to measure lengths to an accuracy of from 0.0001 to 0.0002 in. by this method.

TABLE 3 MEASUREMENTS WITH A STAGE MICROMETER OF A $^1/_2$-IN. GAGE BLOCK

Magnification	10	25	50	100
	0.5001	0.5000	0.5001	0.5000
	0.5001	0.5001	0.5000	0.4999
	0.5000	0.5000	0.5000	0.5000
	0.4999	0.4999	0.5000	0.5000
	0.5000	0.4999	0.5000	0.5001
	0.4999	0.5001	0.4999	0.5001
	0.4999	0.5000	0.5000	0.4999
	0.4998	0.5000	0.5000	0.5000
	0.5001	0.5000	0.5000	0.5000
	0.5001	0.4999	0.5001	0.5000
Mean	0.49999	0.49999	0.50001	0.5000
Sum of errors in tenths	0.0009	0.0005	0.0003	0.0004

Table 3 presents the results of measuring a 1/2-in. gage block ten times successively with each of the powers. Inspection of the data shows that the greatest single error with 10× was 0.0002 in. and 0.0001 in. with each of the other magnifications. Nine units of error of the magnitude 0.0001 in. were made in the 10×, five in the 25×, three in the 50×, and four in the 100×. The probable error of a single measurement with 10× is as high as 0.0002 in. and 0.0001 in. for higher powers. The mean of the ten readings is independent of the power and is constant at 1/10 of a ten thousandth. It is worth reiterating that the error is independent of the size of the object or of magnification deficiencies of any kind and is a function only of the accuracy of coincidence error, which will be eliminated to a large extent by repetition, and of errors of the measuring mechanism. With the universal use of gage blocks, this latter source of error can be reduced to negligible proportions.

The limits of accuracy set forth here are what experience and study have demonstrated to be possible with the latest optical system available. Statements are frequently seen in literature and propaganda that much higher accuracies are possible and available, but their veracity is open to doubt. It is certain that experienced users of this apparatus can claim no more than is claimed here, and the operator must have the latest and best of optical equipment available and must manipulate it painstakingly to achieve these results. The data given indicate that the direct measurement of an image does not lead to extraordinarily high accuracy as we think of measurement today, but do indicate that operation of the instrument as a comparator and as a measuring instrument with auxiliary measuring devices results in a satisfactorily high degree of precision.

In conclusion, the advantages of contour projection over other methods can be summed up as follows: (*a*) As a reproduction comparator it is probably without equal, (*b*) permanent records are provided, (*c*) transcendental curves can be reproduced to a high degree of accuracy, (*d*) measurements are entirely free from the distorting effects of mechanical devices, (*e*) it is extremely rapid in use, (*f*) many things that cannot be measured at all by other means can be measured or compared or both by projection, (*g*) results are practically devoid of the effects of wear in the parts of the device, and (*h*) all parts of an object within the field can be observed simultaneously.

Fig. 4 shows a newly developed projection device, designed to permit the application of these principles in such a manner as to exhaust the possibilities for accuracy and convenience to the extent discussed in this paper. In the illustration, the machine is equipped with a screw and hobholding device, and a thread gage is being projected at a magnification of 25×. If desired, the thread-holding device can be replaced with centers, or a plain table that is adapted to receive any special workholders can be used.

While the brilliance of the image permits the projector to be used under ordinary conditions of room illumination, a curtain is provided to shade the screen from direct light. For opaque specimens, a surface illuminator is provided.

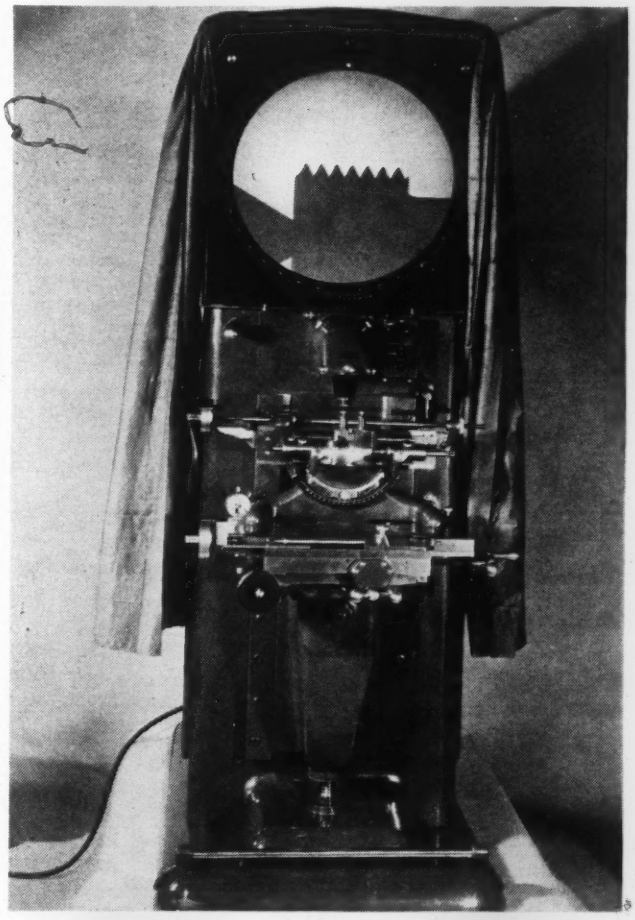

FIG. 4 PROJECTOR EQUIPPED WITH A SCREW AND HOBHOLDING DEVICE
(Note brilliance and crispness of image of thread gage projected at a magnification of 25×. Photograph not retouched.)

SHARE-WAGES

By OLIN INGRAHAM

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE PROPOSAL of Allen W. Rucker in "Labor's Road to Plenty"[1] is that total wages should be made a predetermined share of the total value added by each business concern. By value added he means the gross receipts minus the outside payments for inventories and other outside expenses, but not minus the interest on the debts. He believes that if this were the wage system adopted everywhere it would, in the first place, minimize business-cycle unemployment. In the second place, it would lead each group of laborers to cooperate with their employers, because, by increasing output in each concern, wages would be increased in each concern. This would result in the "plenty" referred to in the title.

First consider share-wages and the business cycle. Some have argued that lowering wages in a depression lowers purchasing power—sends us into a tail spin. But what may be true of an even fall of wages all around would not be true if wages fell only in those industries and those concerns which were struggling hardest to keep above water and would not be true if such fall in wages accompanied a corresponding fall in prices which prevented a shrinkage in goods sold and therefore a shrinkage in employment in the production of goods to be sold.

No business cycle hits industries and concerns evenly. Those hit hardest should make the greatest price concessions, but they can only do this if their cost prices diminish. Labor, directly or indirectly, is their greatest cost. An all-around system of share-wages would, of course, minimize the business cycle by evening the conditions between businessmen.

We maximized the business depression that started in 1929 by having a pricing system in which prices fell most where demand fell least, and fell least where demand fell most. The demands of society for grains fell but little but the price at the wholesale markets fell in 1933 to 39 per cent of the level of 1929. To the farmer it fell much more. It fell to 28 per cent. The farmer was separated from the wholesale market by railroad rates which were not reduced during the depression. In fact, the railroads asked to have them increased. On the other hand, the demand of society for metals fell greatly because the demand of society for long-time capital goods fell greatly, but the index price of metals fell at its lowest to 76.6 per cent of its 1929 price level. It's a crazy world when one is asked to exchange twice as much of what he continues to desire for the same amount of something for which his desires have diminished. That was what people were asked to do in 1932. They did not make the exchange. So the skies of Pittsburgh brightened and looked down upon unemployed men.

The farmer continued to produce under reduced prices, because he took his loss as his own employee, and because he immediately cut the wages of his farm hands. In this depression just as in the depression of 1920–1922, as soon as farm prices fell, wages fell, and by almost the same percentage. In the South, cotton is raised by share croppers; the fall of the price of cotton automatically reduces what is in effect wages.

But it was different in the metal industries. Their leader joined the famous conference with President Hoover in the autumn of 1929 and agreed that wage rates should be maintained; that agreement meant that prices should not be cut much. The same wage rates were continued till 1931. Then there were small adjustments downward which permitted an altogether inadequate fall of prices. It is to be noted that this rigidity of wages and prices was maintained under nonunion conditions. Since then we have a new unionism which has increased the cost of metals. We have had a new recession. On April 13, 1937, farm products were 103.2 per cent of their 1926 levels, metals 110.7 per cent. On April 13 of this year the prices of farm products were 77.5 per cent, metals 102.5 per cent. The world is still crazy. Mr. Rucker will have to convert businessmen as well as labor before we can have flexible prices all around, flexible wholesale prices as well as flexible wage rates. Without flexible prices all around we can't do much as far as prices are concerned in mitigating business depressions.

I am not assuming that flexibility of prices alone is a complete cure. Mr. Rucker wishes us to go back to our American past. Let's go back 100 years. We were then in a depression, probably the worst we ever had except the present one. And it was bad in spite of the fact that we were then a nation of farmers and small businessmen, that our wages and prices were pretty flexible, that labor unions existed only in local forms. Nevertheless, if Mr. Rucker's thesis had been share-wages as a help to stable jobs, I would have agreed with him.

But Mr. Rucker's thesis is that share-wages is "Labor's Road to Plenty," and I don't see it. The largest body of wage earners that have in effect share-wages at the present time are the share croppers of the South, and they have not plenty. Mr. Rucker's argument sounds self-evident. Make a bargain by which both sides directly and proportionally gain by increased output and both sides will cooperate in increasing output. If we find by experience that output under such circumstances is not high, then we may come to the conclusion that emotional cooperation is not nearly as important as a proper coercive organization.

But so far as a share-wage system is in effect, it is a system by which concerns and industries that are in difficulties get their labor cheap, by which prosperous concerns and prosperous industries pay more than the average wage. Now in the nature of the case, any wage system is to some extent a share-wage system. Concerns that are dwindling will be left with employees who have grown old in the service, own their homes, and will not readily move even if the wage rate is lower than elsewhere. Concerns that are expanding will have to pay enough to attract more and more employees from outside. In this rough sense share-wages must be a factor in the wage system under either individual bargaining or collective bargaining. Mr. Rucker has interesting tables to show the difference of employment and purchasing power of laborers in the more productive industries as compared with the less productive industries. The only question is whether it is labor's road to plenty to maximize or minimize this share-wage factor.

How could we minimize it? Suppose a case of perfect in-

(*Continued on page 480*)

[1] "Labor's Road to Plenty," by Allen W. Rucker. L. C. Page and Company, 1937.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

BOILER OPERATION *as It* AFFECTS PRIME MOVERS

By S. E. TRAY

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THE PERFORMANCE of boilers for the generation of steam has received considerable attention in the last decade by those concerned with the design and operation of steam power stations. The term "boiler" has been enlarged to include all the equipment concerned with the generation of steam, including the various devices for heat recovery which form an integral part o modern installations. The operation of this equipment to produce steam at maximum efficiency and economy has been the subject of numerous studies by many investigators. Until recently, however, less consideration has been given to the effect of boiler operation on prime movers and the relation between steam conditions and turbine performance. With the advent of superimposed turbines in central stations and high-back-pressure units in industrial plants with large process-steam requirements, the problem of their continuous operation at maximum efficiencies has become more acute.

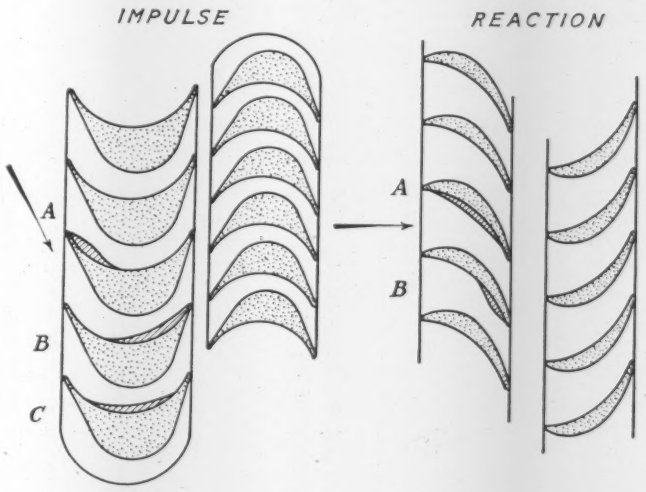

FIG. 1 TYPICAL DEPOSITS ON TURBINE BLADING

A survey of any group of high-pressure steam plants brings out forcibly the fact that turbine-blade deposits with attendant problems are practically universal. In spite of this, however, there is an appalling lack of available information of such a nature that it can be readily applied to correcting these conditions in the field. This is due in part to the difficulty of studying steam conditions in the field and also to the fact that turbine performance has not been generally considered as a function of boiler operation. While it is obvious that steam quality is a direct result of boiler-water conditions, and likewise, that turbine operation depends largely on the quality of steam supplied to the throttle, these facts have not been properly presented to those concerned with operation.

PRIMING, FOAMING, AND CARRY-OVER

In discussing steam conditions as they relate to turbine operation, the terms priming, foaming, and carry-over are in common usage. They are not synonymous, however, and, for the sake of clarity, will be defined according to their generally accepted meaning. Priming is considered to mean the lifting of water into the steam space of a boiler from the rapid release of steam at the evaporating surface. It occurs with no regular frequency and results in actual slugs of water passing with the steam through the superheater to the turbine Foaming occurs when a layer of steam bubbles is formed on the surface of the water in a boiler drum. As these bubbles fill the steam space, the liquid films are carried along with the steam as moisture. Carry-over, on the other hand, means the constant expulsion of small quantities of moisture into the steam space even in the absence of foaming and priming. In the superheater, the moisture is evaporated, and the solids remaining are carried along with the steam to the turbine. Priming is frequently a mechanical problem, associated with high water levels, circulation, and insufficient steam releasing space. Foaming more often occurs due to water conditions in the boiler. Foulk (1)[1] and his associates have reported on the effect of various soluble and suspended solids in producing foaming tendencies and the effect of these on surface tension. The presence of superheater and turbine-blade deposits in many instances where neither foaming nor priming are evidenced points to the need for eliminating the effect of carry-over in power-plant operation.

The effect of steam contamination of any type on the operation of steam turbines is manifold. Deposits in nozzles and valves and on blading, and corrosion of cylinders, shafts, and blading all result from improper steam conditions. Even a small deposit will change the contour of the blading and materially decrease the efficiency and capacity of the turbine. Fig. 1 shows the effect of deposits on sections of impulse and reaction blading and, in both types, the reduction in area between the blades restricts the flow of steam through the turbine. In addition, faulty operation of flowmeters, sticking of admission and reducing valves, and impaired operation of traps and drains are among the operating troubles caused directly by contaminated steam.

CAUSES OF CARRY-OVER

While the phenomenon of carry-over is still a subject of controversy among various authorities (2), investigations by the author point to four important factors that influence steam conditions in varying degrees. These all relate to boiler-water conditions and include alkalinities, suspended solids,

Contributed by the Power Division for presentation at the Semi-Annual Meeting, St. Louis, Mo., June 20–23, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

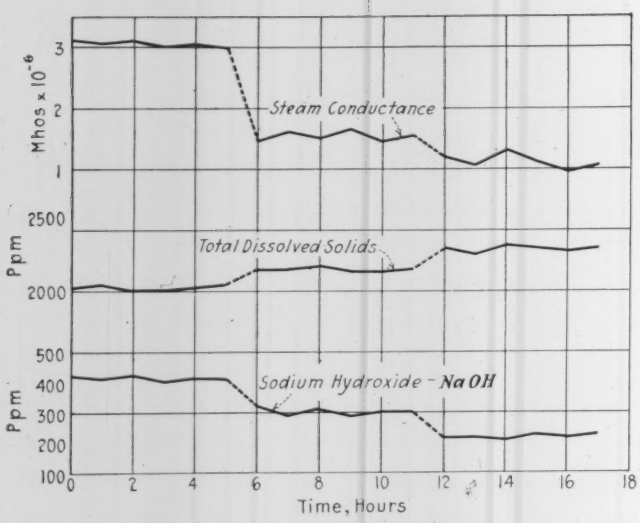

FIG. 2 EFFECT OF BOILER WATER ON STEAM

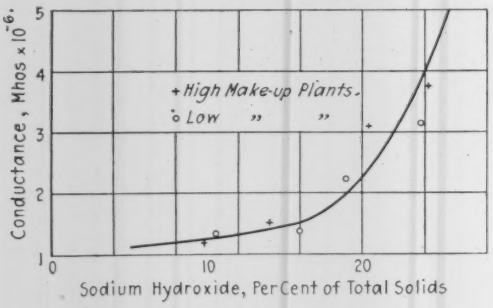

FIG. 3 EFFECT OF ALKALINITY ON STEAM QUALITY

total dissolved solids, and organic matter. The exact manner in which these factors exert their influence is still a subject for investigation, but the purpose of this paper is to indicate the effect of the various factors on steam conditions and methods of counteracting their influence. The effect of alkalinity on carry-over is of particular importance not only because it is one of the easiest factors to control but also because of the extreme sensitiveness of steam conditions to boiler-water alkalinity. Fig. 2 shows the effect of a reduction in caustic alkalinity on steam conditions. Tests were made in a 600-lb boiler, of bent-tube design, supplied with 100 per cent make-up treated in a zeolite softener followed by acid treatment. Boiler-water alkalinity was adjusted by changing the acid feed, and it is to be noted that a decrease in alkalinity was accompanied by an increase in total dissolved solids. Blowdown was continuous, and both blowdown and steam generation were held constant during the test period. To obtain a better understanding of the effect of alkalinity, Fig. 3 shows the conductance of steam as a function of the ratio of caustic alkalinity to total solids. It was felt that such a means of expressing results would be advantageous in comparing boiler-water conditions in low-make-up plants where total solids were much less. This appears to be borne out by indicating on the curve in Fig. 3 results of similar tests in low-make-up boilers where alkalinities were adjusted by a change in chemical treatment. This effect of alkalinity has been previously noted by Mumford (3), but the effect of the ratio of alkalinity to total solids has but recently been investigated.

A study of these test results shows that the total dissolved solids exert less influence on carry-over than does alkalinity. An increase in total solids by itself does not result in more carry-over unless such increase is accompanied by an increase in the ratio of alkalinity to total solids. It will be noted that the curve in Fig. 3 changes slope when the alkalinity is approximately 17 per cent of the total solids, and a further increase in this ratio results in a more rapid increase in conductance of the steam. This may account for some of the difficulty from carry-over encountered in boilers operating with a low percentage of make-up and low total solids. In this type of operation, the alkalinity may be a greater percentage of the total solids than is the case when the boiler water contains a higher dissolved-solids content. The required adjustment in alkalinity can be obtained by manipulation of the chemical treatment supplied to the boiler water. In some instances, excessive alkalinities are due to overtreatment beyond the point actually required for scale and corrosion prevention. In others a supplementary acid treatment will adjust alkalinities within the proper operating ranges.

EFFECT OF SUSPENDED SOLIDS AND ORGANIC MATTER

A study of the effect of suspended solids on carry-over immediately presents the fact that different kinds of solid matter produce different effects. There are data (4) to substantiate the idea that suspended solids do not contribute to carry-over, but more evidence to the contrary is found in those boilers operating with high suspended solids. Finely divided precipitates of carbonates and phosphates appear particularly troublesome and until more information is available from representative installations, it would seem advisable to reduce the suspended matter as low as possible. Increased blowdown and internal coagulation or both are effective, but care should be taken that coagulation does not introduce alkaline salts or possibly organic matter into the boiler water. In such cases, the cure is often worse than the disease.

Organic matter in boiler water has not received the attention it deserves especially for operation at higher pressure. It is seldom encountered in central-station practice except from condenser leakage and then only in minute quantities. With high-pressure operation and high percentages of make-up, however, organic matter is found to contribute materially to the inability of boilers to carry high concentrations without carry-over. In many cases its presence is not even suspected, as certain organic matter does not materially change the color of boiler water. Tests were recently made on a 600-lb boiler operating with 50 per cent make-up, using city water treated in a hot-process softener. Above 1000 ppm total solids, considerable carry-over was observed which increased as the concentrations were raised. Alkalinities and suspended solids

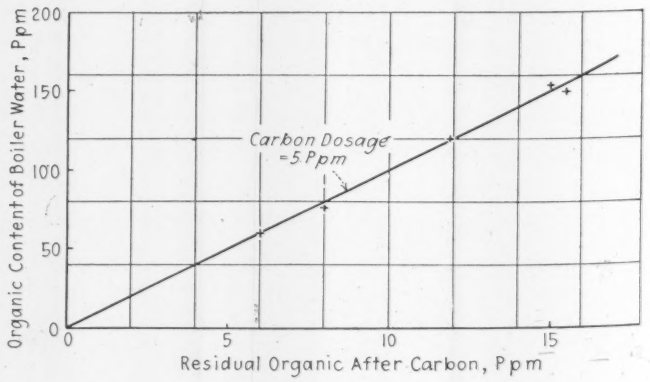

FIG. 4 EFFECT OF CARBON ON ORGANIC MATTER IN BOILER WATER

were low, which led to an investigation of other factors that might contribute to carry-over. It was found that the total solids as calculated from the various salts in solution did not check with the total solids determined by evaporation. The difference was due to nearly 150 ppm of organic matter which was subsequently determined separately as a further check. To eliminate this organic matter, a small quantity of activated carbon was fed to the boiler internally, together with sufficient iron as hydrous ferrous oxide to coagulate the suspended carbon. The organic matter was completely absorbed by the carbon, while the iron floc prevented any increase in suspended solids. Carry-over stopped, and, as concentrations were increased to 2500 ppm there was no further evidence of contaminated steam. The use of activated carbon internally at high pressures does not involve any particular difficulty if precautions are taken to provide proper coagulation for the finely suspended carbon particles in the boiler water. Fig. 4 shows the reduction in organic matter in the boiler water resulting from a dosage of 5 ppm of carbon in the feedwater. The rate of absorption of organic matter by the carbon appears to be in direct proportion to the quantity of carbon present.

MEASURING IMPURITIES IN STEAM

In determining the quantity of solids in steam, electrical-conductivity measurements have been widely used because of their increased sensitivity. Impurities in the steam must be determined in amounts of the order of 1 ppm or less which requires not only careful sampling but also elimination of dissolved gases if absolute measurements are to be obtained.

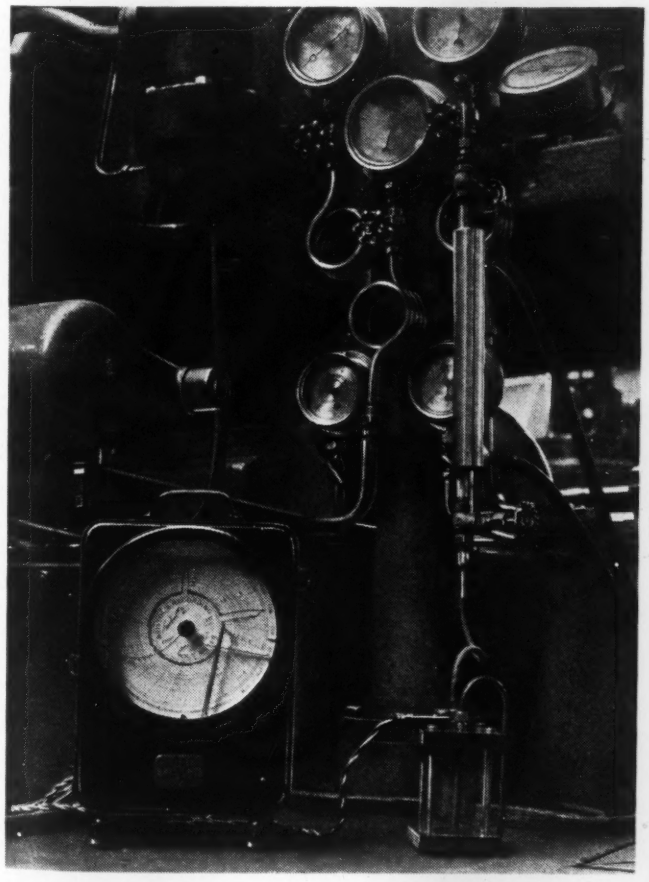

FIG. 5 CONDUCTIVITY METER FOR MEASURING STEAM QUALITY

Descriptions of various methods used have been reported by Rummel (5), Hecht and McKinney (6), and Place (7) which involve detailed laboratory procedure and from which a continuous sample is difficult to obtain. Place points out that the error in the conductivity method lies not so much in the measurement itself as in the conversion of the conductivity

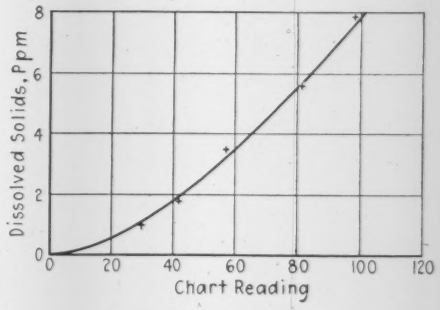

FIG. 6 CALIBRATION CURVE FOR CONDUCTIVITY METER

values to equivalent-solids concentration and in the elimination of or correction for dissolved gases in the steam samples. In studying steam conditions in the field as they affect turbine operation, there is need for a continuous measurement which is relatively correct rather than absolute measurements taken periodically. This need has been met in part by the development of a recording conductivity meter with no correction for dissolved gases. Although this instrument does not give absolute values, the quantity of dissolved gases present in steam is reasonably constant with a given water condition, and only the relative measurements from one time interval to the next are required.

This meter, which is shown in Fig. 5, is simply a recording ammeter connected in series with a conductivity cell through which a sample of condensed steam flows continuously. The steam sample is condensed under pressure which insures that all the gases in the steam will be in solution in the condensed sample. The cell, itself, utilizes stainless-steel electrodes and is designed so that the sample of condensed steam is introduced into the area between the electrode plates so as to avoid any lag in the meter and in such a manner that measurement is obtained of the current flowing across a constant volume of water. An increase in dissolved solids in the steam increases the conductance and is reflected by the recording pen of the meter. In the field, this meter is calibrated against varying quantities of boiler water in distilled water with the pH adjusted to conform to that of the condensed steam. This pH adjustment compensates to some extent for dissolved gases and makes the readings relatively accurate. A typical calibration curve is shown in Fig. 6, which is based on a chart divided into 100 equal spaces. For a boiler operating with total solids of 2500 ppm, a moisture content in the steam of 0.05 per cent represents 1.2 ppm of solids. This low moisture content cannot be detected with a calorimeter but is readily measured by the meter. Even though dissolved gases account for some of the conductance, any variation in steam conditions is at once apparent on the chart.

Typical charts, shown in Figs. 7 and 8, indicate steam conditions from a four-drum bent-tube boiler generating steam at 650 lb and 750 F with a large percentage of make-up. Steam samples were taken from the inlet header of the superheater and condensed under pressure as described. In Fig. 7, the peaks in the curve indicate points of maximum carry-over where the solids in the steam reached a peak of about 6 ppm. Continuous carry-over is indicated by the fact that the meter never recorded

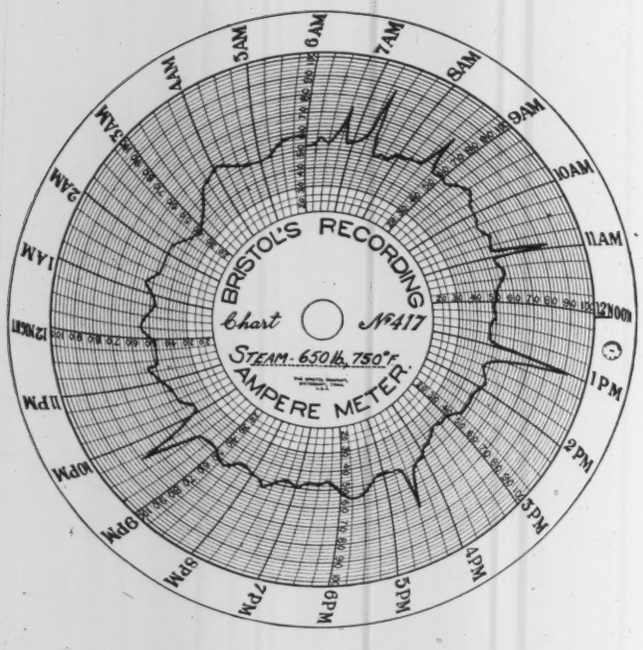

FIG. 7 STEAM CONDITIONS IN A FOUR-DRUM BENT-TUBE BOILER
(Peaks in chart indicate points of maximum carry-over where the solids in the steam reached a value of approximately 6 ppm.)

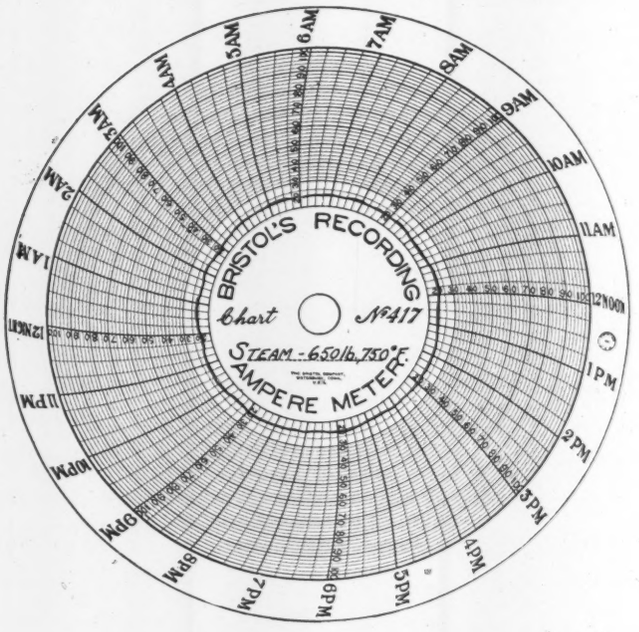

FIG. 8 ANOTHER CHART FROM THE SAME BOILER
(Improvement in steam conditions, by which the solids in the steam were reduced to 0.5 ppm, is indicated by the smoothness of the chart.)

less than 3 ppm of solids. Fig. 8 shows steam conditions from the same boiler under the same load after water conditions had been adjusted to eliminate carry-over. A uniform curve, free from peaks and showing not over 0.5 ppm of solids in the steam, indicates the improvement in steam conditions. Although the use of such a meter gives results that are hardly comparable with laboratory procedure, it, nevertheless, offers a means of determining steam conditions long before deposits make themselves evident in superheaters and turbines. In addition, any improvement in steam conditions, brought about from either a change in the state of boiler water or mechanical changes in the boiler itself, is immediately apparent to the operator.

TURBINE-BLADE DEPOSITS

In analyzing the causes of turbine-blade deposits, one of the first steps is to determine the chemical composition of these deposits. Table 1 shows some typica analyses of various deposits collected from steam turbines operating under variable conditions. Although these deposits are composed of practically all the salts usually found in boiler water, they are not found in the same proportion as they exist in boiler water. This is not due to selective carry-over of various solids from the boiler but rather to selective deposition of certain salts. Straub (8) has pointed out how sodium hydroxide from the boiler water adheres to turbine blading due to the sticky nature of this material in certain temperature ranges. Examination of a large number of blade deposits confirms this explanation and further accounts for the presence of both soluble and insoluble deposits. Soluble deposits are principally sodium oxide and are easily removed by washing with saturated steam. Insoluble deposits, on the other hand, are largely silica with only traces of other constituents. It must be borne in mind, however, that these insoluble deposits represent the material left after all of the soluble salts are washed away, and, hence, they bear little resemblance to soluble deposits. To account for the large percentage of silica found in insoluble deposits, we must consider the behavior of sodium hydroxide as explained by Straub. In addition to the sodium hydroxide present as such in boiler water, there is also a portion normally combined with silica as sodium silicate. Sodium silicate, although usually considered a simple compound, Na_2SiO_3, is actually a complex salt of the form, $xNa_2O.ySiO_2$. When this material is carried over with the steam, the sodium oxide adheres to the turbine blade exactly as does the sodium oxide from the boiler-water alkalinity and in the same temperature ranges. The silica (SiO_2) is deposited with the sodium oxide but forms a hard glassy surface at high temperatures which is impervious to moisture. If from washing or cooling of the turbine, the deposit becomes moistened, the sodium oxide, being soluble, is washed away leaving only the insoluble silica.

TABLE 1 CHEMICAL ANALYSES OF TURBINE-BLADE DEPOSITS

(Composition in per cent)

Steam pressure, lb per sq in.	400	600	600	800	1200	600	1200
Silica, SiO_2	3.2	80.1	81.3	9.3	85.2	1.4	53.9
Alumina, Al_2O_3	5.8	2.1	1.9	2.0	..	6.3	..
Iron oxide, Fe_2O_3	1.8	1.0	2.0	1.2	3.6	4.0	24.6
Sodium oxide, Na_2O	27.3	3.6	10.2	56.3	2.5	33.4	5.6
Calcium oxide, CaO	16.8	0.2	trace	1.9	trace	trace	3.9
Magnesium oxide, MgO	8.2	0.2	..	0.5	..	..	..
Chloride, Cl	..	6.5	trace	10.1	..	..	..
Phosphate, P_2O_5	..	trace	..	9.6	1.7	17.3	7.3
Carbonate, CO_2	36.3	0.5	0.5	9.2	trace	1.2	..
Sulphate, SO_4	..	trace	trace	..	..	1.7	..
Remarks	Sol.	Insol.	Insol.	Sol.	Insol.	Sol.	Insol.

Verification of this explanation is obtained by considering the temperature ranges in which deposits are formed in turbines. Fig. 9 shows conditions in a typical back-pressure turbine operating at 650 lb and 700 F and exhausting at 130 lb with some superheat to process. No deposits are found in the initial stages of the turbine or at any point above approximately the 600-F stage in the turbine. At this point, however, deposits begin to form and continue in increasing quantities to the last stages of the turbine at 435 F. These deposits are both soluble and insoluble, and, upon washing with saturated

steam, the soluble portion is removed. As operation continues, however, and the turbine is subjected to frequent washings, a condition is reached in which washing no longer benefits the machine as the insoluble deposits have built up to an appreciable degree. These insoluble deposits, generally more than 80 per cent silica, are found in the same location in the turbine as were the soluble deposits. In the case of a superimposed turbine exhausting into low-pressure machines or in the case of a straight condensing unit, these deposits are found in the range down to the saturation point in the turbine. Below this point, the steam contains sufficient moisture to wash the deposits continuously from the blades. Similar conditions have been noted in 1200-lb 900-F turbines where deposits form in approximately the same temperature range, indicating that initial throttle conditions do not materially affect the zone in which these deposits are found. This consideration of turbine deposits points strongly to the fact that the nature of the solids in the steam determines to a large extent whether deposits will form on the blading.

SOLIDS IN STEAM

The elimination of solids in the steam has been the concern of both boiler and turbine manufacturer alike. Development of various types of steam washers in modern boiler installations has been a logical step in this direction. By replacing the concentrated boiler water in the steam with feedwater containing a lower solids content, a definite reduction is effected in the resulting solids in the steam. The only change in the nature of the solids by this method, however, is due to the difference in the nature of the salts in feedwater as compared to boiler water.

If the feedwater is for the most part condensate, as in central stations, this change is appreciable, but in the case of high-make-up plants, the change is sometimes of a minor character. From tests on various types of washers in the field, about 25 per cent of the moisture in the steam is due to boiler water after passing through the scrubbers. Even though the solids are reduced to a value of 0.5 ppm leaving the boilers, this can result in appreciable deposits in the turbine if the salts are of such a nature as to adhere to the turbine blades. Since it is

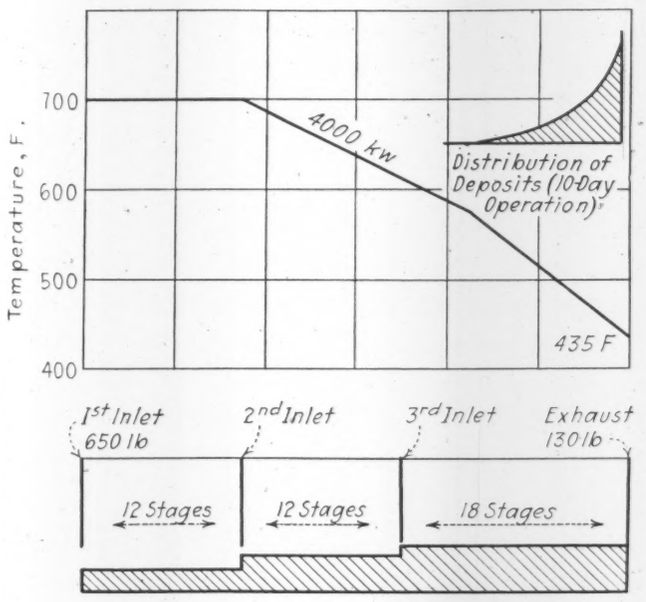

FIG. 9 INFLUENCE OF TEMPERATURE UPON FORMATION OF TURBINE DEPOSITS

FIG. 10 EFFECTS OF SILICA IN BOILER WATER UPON TURBINE DEPOSITS

hardly practical to reduce the solids in the steam below the point now obtainable by steam washers, the ultimate solution of the problem appears to lie in the direction of changing the nature of the solids in the steam.

This leads us back to the water conditions in the boiler since it has been demonstrated that sodium hydroxide and silica carried over from the boiler water are responsible for the majority of turbine deposits. If the boiler water contains a minimum of both of these salts, then the moisture carried over in the steam will likewise contain a negligible quantity of these two compounds, independent of the total solids present. Obviously, sodium hydroxide cannot be eliminated from boiler water as a sufficient quantity must be present to keep the pH value of the boiler water in the range between 10.5 and 10.8 to prevent corrosion. Any excess over this, however, is undesirable particularly if the hydroxide becomes too great a percentage of the total solids. The alkaline treatment supplied to boiler water should, therefore, be adjusted to produce only the minimum required alkalinity in the boiler. The quantity of soluble silica that can be safely carried in the boiler is thus far only a matter of observation. Table 2 shows the percentage

TABLE 2 BOILER-WATER CONDITIONS IN PLANTS HAVING INSOLUBLE TURBINE-BLADE DEPOSITS

Station	Pressure, lb per sq in.	Total solids, ppm	Silica		
			Ppm	Percentage of total dissolved solids	Insoluble deposits
A	400	2200	47	2.15	Yes
B	400	1800	12	0.67	No
C	500	1800	20	1.12	No
D	600	750	20	2.67	Yes
E	600	2425	126	5.20	Yes
F	600	320	5	1.56	No
G	700	2800	2	0.07	No
H	700	2150	8	0.37	No
I	1400	480	15	3.12	Yes
J	1400	220	2	0.91	No
K	1400	785	23	2.93	Yes

in boiler water compared with the total solids in a number of plants, some of which have experienced insoluble deposits in the turbine and others which have not. If the soluble silica is plotted as a percentage of the total solids, as in Fig. 10, it is evident that silica cannot exceed 2 per cent of the total solids if insoluble deposits are to be prevented. While undoubtedly plants are operating with a higher percentage of soluble silica without deposits, it is important to note that those plants

having insoluble deposits fall in a range above 2 per cent. The necessary reduction in soluble silica in boiler water can be accomplished by feeding iron in the form of a hydrous oxide internally in the boiler. This results in the precipitation of silica as a sludge with iron and accomplishes a greater reduction than is possible with the use of iron externally because of the effect of temperature on the solubility of silica. Not only is a reduction of soluble silica beneficial from the standpoint of turbine operation, but it also eliminates the tendency for complex silicate deposits on the heating surfaces in boilers. Excessive concentration of soluble silica in boiler water is responsible for operating difficulties both in boilers and in turbines.

In the case of high-make-up plants using feedwater containing 15 to 30 ppm of silica, the question may well be asked, how can the effect of this silica content be eliminated if this feedwater is used in a steam washer? Silica in feedwater is present as the result of dissolving silica from the earth's crust, and exists in the uncombined form. If silica in this form is carried along with the steam, it will not deposit on turbine blading. This is because there is no sodium hydroxide present to act as a binder, as is the case with sodium silicate as it exists in boiler water. In the same manner, a plant using external treatment with high make-up requirements should be particularly cautious that no sodium-hydroxide alkalinity is present in the feedwater as a result of external treatment. If hydroxide alkalinity exists in the feedwater used through a steam washer, deposits are practically sure to form from the moisture in the steam due to feedwater. While the steam washer is a valuable adjunct to the production of clean steam, it has definite limitations particularly in those plants where the feedwater contains an appreciable percentage of treated makeup water.

The problem of boiler operation and its effect on prime movers becomes increasingly important as pressures and ratings increase in steam power plants. All of the 1400-lb plants now in operation have low make-up requirements and operate with total solids in the neighborhood of 500 ppm. Several high-make-up plants are contemplated in the future for operation at 1400 lb and higher. Whether it will be feasible to design such plants and operate them with the higher concentrations necessarily required from increased make-up, will depend on how these conditions are reflected in turbine operation. To a large extent, the future of such plants will depend on the information obtained from present installations. If this brief consideration of the factors affecting prime movers will promote further investigation of this important problem, then its purpose will have been amply fulfilled.

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Share-Wages

(Continued from page 474)

dividualism, where every laborer was intelligently foot-loose. Then it would not take much of a wage differential downward to deprive the struggling employer of the best of his labor force. It would not take much of a differential upward to allow the prosperous employer either to skim the cream of the labor force or to expand the labor force. Now there is no question but that this would be labor's road to plenty because it would be the community's road to plenty. It would be the way by which the community could most rapidly expand its output by expanding its most efficient concerns and industries, and by contracting its least efficient concerns and industries. But this would not be wages that shared in the output of industries located where the worker was. It would be wages determined by the output of industries which were located where the worker might go.

My illustration was perfect individualism. If we had perfect individualism it would be silly and clumsy to have either unionism or governmental control. We don't have perfect individualism. We don't have a labor force that is intelligently foot-loose. Most of the labor force are not foot-loose; they are married, own their homes, are tied to their own friends, clubs, and churches. Most of the foot-loose laborers are not intelligent. Their wandering does not get them anywhere. So if we left it to individuals, a labor force would stay put and over long intervals might receive less than other equivalent labor forces.

Take the example of the Southern Appalachian region. The southern cotton factories could hire their labor force at lower rates than in New England because wretched farms were the only other alternative. The wretched farms continued a real alternative because the southern whites stayed up in their hills while for a hundred years other men marched west to better farms. Intelligent individualism would have let those farms go back to wilderness. There was not enough of intelligent individualism there. That's the argument for Tennessee Valleys on the one hand, as it is for labor-union activity on the other.

Their crude results may approximate more closely to the results of intelligent individuals than to the results of unintelligent individualism. If a government puts a floor under wages irrespective of whether that means the death sentence of certain concerns or industries, it actually carries out crudely the death sentence which intelligent individualism would also have forced upon those same industries. Of course, to lay the floor down in a time of unemployment is to lengthen the depression. So for the unemployment of the present, share-wages is a mitigation; for the progress of the future share-wages is an obstruction.

In this review I have considered only the main idea, but the reader will find Mr. Rucker's execution brisk, keen, and pungent. He has a flair for significant tables and charts. There is one statistical criticism that could be made, not of Mr. Rucker but of the United States Census. In many of the census reports on manufacturing, the total of salaries and salaried workers is not given. Salaried workers include not merely the few people in positions of control but the multitude of the white-collar class. In such reports "wages" average only about one third of total value added and this fraction Mr. Rucker would wish to use as the base for share-wages of the future. Seen by itself it looks as if twice as much were to be given to capital as to labor. Of course it would not be two to one if "salaries" were added to "wages."

How Useful Is Your SENSE OF PROPORTION?

By W. E. JOHNSON

With Illustrations by A. Mark Smith

GENERAL ELECTRIC COMPANY, FORT WAYNE IND

WHAT IS your sense of proportion? Whatever it may be, it is one of the most useful attributes a designer can possess. It enables him to visualize and draw a complicated machine or structure, sufficiently close to the correct proportions so that little analysis is required to perfect it. Certainly, it is well known that a man not having a well-developed sense of proportion does not make the best designer.

The term "proportion," in arithmetic, denotes the ratio of one number or distance to another and is essentially a concept of linear relations. A "sense of proportion," of course, permits one to estimate fairly closely whether one member is double, one half, one quarter, or one third the length of another, but it certainly is not limited to that. There appears to be some appreciation of the squares and cubes of quantities, although this may, to a great extent, depend upon one's experience. Whatever the source, this faculty is present in primitive animals and birds. Have you ever seen a bird light on a twig and fall off because the twig broke? I haven't, except among the notoriously stupid poultry; and the members of the simian tribe, swinging from bough to bough, always seem to know when the section modulus is sufficient for their needs, in spite of the fact that the only sheepskins they are familiar with have sheep inside of them.

How often the junior engineer, making a start in design work, is embarrassed by having sheets of complicated calculations consigned to the wastebasket by the brusque and apparently arbitrary statement of his chief that it is "no damn good!" And the junior's realization that his boss, the chief designer, is a "practical" man with no college training does little to soothe his feelings. Then later, when he finds a mistake in calculation or realizes a mistake in judgment, he is subdued, feels inwardly sheepish, and would enjoy a quiet half hour kicking himself, could it be done by proxy. Later still, he begins to wonder why it is that a man with nothing more than an intuitive or acquired sense of proportions, plus some experience, can with impunity short-circuit hours of cold, mathematical reasoning and with seemingly miraculous perception arrive so close to the correct result.

Of course, as the junior, following the natural course of life, begins to show his scalp and forget his sheepskin, he begins to take on some of his chief's attributes. He inclines to rely more on judgment and less on textbooks. But still, he cannot give the cause of this attitude any better name than experience.

It is interesting to contemplate how far a designer may go in his reliance on judgment, or sense of proportion, without being led astray. Dimensional analysis is a convenient tool for such an investigation, and it has the advantage of revealing those fundamental relations which, in so many cases, make it possible to design things "in proportion" or by "rule of thumb" successfully.

'. . . . the notoriously stupid poultry.'

Of course, we should realize that most designers are in one line of business most of their lives. Automobile-engine, compressor, motor, and turbine designers, each of them tends to remain at the task of designing one particular line of product. Consequently, the designer's sense of proportion usually is called upon only for making larger, smaller, faster, or slower machines of the same general type. Naturally, having experience with one or two machines, proportioning a larger or smaller one does permit the use of one's sense of proportion to a high degree, and the designer would be foolish indeed if he disregarded his experience with previous designs. However, even here it is not always safe to rely on proportionate design, without the support of more fundamental reasoning.

In recent years, I have become interested in this problem of so-called practical design and have wondered to what extent designers of the past have been justified in designing engines, for example, by proportioning everything to the cylinder bore. It happens that my own job is compressor design, and, while much that I may say would apply also to engine design, I will, if you please, restrict my examples to problems of compressor design. Let us consider some problems involved in the correct proportioning of a line of compressors and then see to what extent rule-of-thumb designing is permissible. Understand that we shall first deduce proportions by the method of cold reasoning, and then see whether the results justify the other method.

AN EXAMPLE ON THE EFFECTS OF VALVE DESIGN ON SPEED

Assume that we have built and have had satisfactory experience with a large compressor and that we wish to make a smaller one having essentially the same arrangement of parts and the same number of cylinders. Let us begin by studying the effects of valve design.

In any compressor, the problem of valve design is one of obtaining the required flow of gas into and out of the cylinder with a minimum of power loss from pressure drop through the valve ports and a minimum volumetric loss from clearance volume. The faster a compressor can run, the more capacity a given size will have, and, consequently, the lower cost. On the other hand, valve losses will increase with speed, requiring relatively more power, so that an economic balance must be struck somewhere. Obviously, the valve design is one of the major factors limiting speed. Consequently, the valve-design problem is one of providing the maximum possible area for the gas passages.

The majority of practical valve designs will

permit the port area to be in rough proportion to the piston area. Assuming this to be the case, it is easily shown that the proportion of work lost by valve restriction will remain constant if the velocity of gas through the ports remains constant in the two cases. Now, since the valve-port and piston areas are in proportion this means that the average piston velocity must be the same in each case. This is the first basic relationship.

It can be shown, from a study of other factors involved, that we are justified in keeping the same ratio of bore and stroke. Assume this to be true. The volumetric capacity of the compressor will then vary as the cube of the bore diameter and as the speed, or $C \propto D^3N$, where C = capacity, cfm; D = cylinder bore, in.; and N = shaft speed, rpm. Now, the mean piston velocity is $V = 2SN \propto DN$, where S = stroke, in.

If we wish to keep this constant, the capacity will vary as $D^2V \propto D^2$. For example, if our small compressor is to have one fourth the capacity of the larger, we should use one half the bore and stroke, and the shaft speed should be doubled. Any higher speed than this will mean excessive valve loss, and a lower speed will require a larger compressor than necessary.

How is this theoretical result influenced by practical considerations? These, I think, are the principal ones:

(1) In small compressors, it becomes increasingly difficult to provide screws and fastenings of practical, standard sizes, for the valves. Consequently, some of the possible port area is lost. It is also difficult to drill the large number of small holes that are theoretically required for ports, and because of this, the tendency is to change the valve design to one that is not so efficient but is easier to make.

(2) When, with increasing speed, the compressor speed indicated is near that of the driving motor, the tendency is to restrict the compressor to motor speed and take advantage of direct connection. This, of course, will modify the compressor proportions.

(3) In small, high-speed compressors, such as those used for household refrigeration, there is a tendency to use a bore somewhat larger than the stroke to (*a*) lower the piston speed, and make the valve design less expensive, and (*b*) obtain a larger cylinder and valve size that will adapt itself better to standard methods of production.

(4) The size of the crankcase must be large enough to hold the required oil supply. This is usually greater, per unit capacity, on the smaller compressors. Hence, reduction of the cylinder size beyond a certain point will not appreciably reduce the size of the compressor.

'. . . . consigned to the waste basket . . . . by his chief.'

Taking account of these natural modifying tendencies and judging by the diversified compressor designs that have been placed on the market, it appears that compressor designers, on the whole, have not been fully aware of the basic relations between speed and capacity. Even allowing small compressors a piston speed of two thirds that possible on larger machines, the speeds of most small conventional compressors are too low, although in the last year or two high-speed, reciprocating refrigerant compressors of 2 or 3 hp rating have begun to make a serious showing on the market. In this particular case, I think we must admit that our sense of proportion has been rather slow in producing the logical result. We needed more of that cold reasoning.

'. . . . a quiet half hour kicking himself.'

If we consider that the head and suction pressures are the same in each case, it follows that the load per unit piston area will be the same. Consequently, if the bearing area is kept in proportion to the piston area, the bearing pressures will be the same in each case. This is common practice, and so far, so good. But bearing design, if we fully realize the requirements, needs a more intensive study than this. We need to know something about the shaft deflection, clearance required, oil viscosity, and power consumption.

It can be shown that, if we assume perfect alignment of a journal with respect to its bearing, the ratio of minimum oil-film thickness to the bearing clearance is a function of the ratio of length to diameter, and of the quantity $\mu N/Pr^2$, where μ = absolute viscosity, N = angular shaft speed, P = bearing pressure, and r = ratio of bearing clearance to diameter.

Now, if we keep the same ratio of length to diameter on the small compressor as on the larger one and if the bearing pressure and the clearance ratio are the same in each case, we will obtain the same relative minimum film thickness in each case if we keep the quantity μN the same. This will require the absolute viscosity to be in inverse proportion to the speed. For the sake of clarity, let us summarize these results so far:

(1) Bearing pressure in each case is the same
(2) Ratio of length to diameter of the bearing is the same
(3) Ratio of bearing clearance to diameter is the same
(4) Viscosity is decreased in proportion as the angular shaft speed is increased
(5) Under these conditions, the minimum oil-film thickness in each case will be in proportion to the shaft diameter.

These results are based on the assumption of perfect alignment. Actually, the shaft will deflect under load, and this deflection will cause localized bearing pressures that may cause failure of the bearing. For any given combination of journal and bearing materials, the best criterion for judging the relative hazards involved is the ratio of this deflection to minimum oil-film thickness. In using this criterion, we shall neglect the effect of curvature of the shaft within the bearing.

Now if the two compressors are dimensionally similar, the load on the shaft will vary as the piston area or as D^2, and the moment arm will be roughly proportional to D. Consequently, the bending moment varies as D^3. Also the deflection of one end of the shaft, considered as a cantilever, is propor-

tional to ML^2/D_1^4 where M = maximum bending moment; L = length of moment arm; and D_1 = diameter of shaft, $\propto D$.

Since $M \propto D^3$ and $L \propto D$, the maximum deflection at one end of the bearing will be proportional to $ML^2/D^4 \propto D$.

From this result, we can see that if we make the bearings and clearances in linear proportion to the cylinder bore, we shall have a journal deflection in each case that is proportional to the minimum oil-film thickness, provided we vary the viscosity in inverse proportion to the speed. This is a remarkably satisfactory result.

Now what about the power loss? Accepting the proportions derived so far, which give us the same relative film thickness in each case, we can show that the friction power will vary as

$$\mu LD_1^2N^2/r \propto \mu LD^2N^2/r$$

The useful work performed by the compressor is proportional to the displacement rate, which in turn is proportional to D^3N for the same number of cylinders. Consequently, the ratio of friction power to useful work is in proportion to

$$\mu LD^2N^2/rD^3N = L\mu N/rD$$

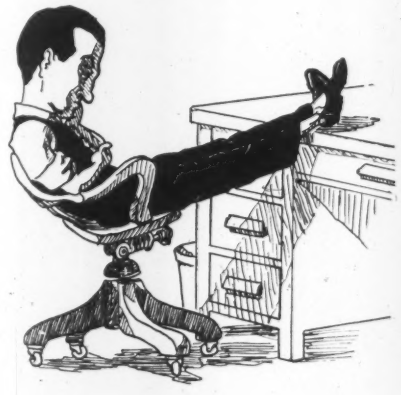
but since we made L proportional to D, made r the same in each case, and made the viscosity inversely proportional to the speed, it is apparent that this expression remains constant. In other words, the bearing-friction loss will bear the same ratio to useful work in either compressor.

Summarizing the entire problem of bearing design, it appears that the use of plain linear proportionality of bearings to cylinder bore will produce all the desired technical results, provided the oil viscosity bears the proper relation to the speed. Considering the inherent complexity of the bearing problem, this is really a remarkable result. Nevertheless, it should be stated that there are one or two practical factors affecting the proportions of compressor bearings, namely:

(1) Nature generally refuses to make the size of dirt particles vary with the diameter of the bearing, so that there is more risk of failure from this cause in small bearings than in large ones. This introduces a tendency to reduce bearing pressures somewhat in small compressors unless dirt can be excluded.

(2) There are physical limitations on the refinement of size and finish that can economically be produced in the factory. Consequently, there is a tendency to allow relatively more clearance and use a heavier oil in small machines than is otherwise called for. This also aids the bearing in handling dirt.

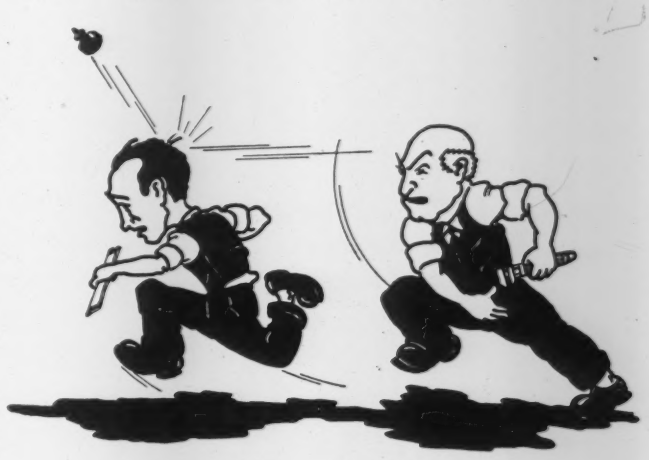
Probably you recall the old handbook rules for designing engines, in which every part was made in some proportion to the bore. In spite of the apparent crudeness of the method, it is evident that it has a reasonable background, whether its instigators knew it or not. In general, it may be said that our practical designers, relying chiefly on a sense of proportion have come remarkably close to the correct answer. Of course, they have failed at some points; most notably in a lack of appreciation in many cases of the basic relation between speed and oil viscosity. This is understandable, because the dimensions of viscosity and their significance are not easily grasped by the nontechnical mind nor does viscosity easily present a picture in the mind that can be proportioned as geometrical properties are. With concepts of this nature, one's innate sense of proportion needs the additional support of logic.



'. . . . the necessity of painful thinking.'

AN EXAMPLE IN THE DESIGN OF SURGE VOLUMES

Before leaving these examples, I wish to present one more, relating to the design of surge volumes, which are spaces that are provided either on the suction or discharge side of a compressor and permit the cylinder to draw or discharge gas with less pressure drop than would occur if the cylinder were connected directly to the pipe line. Ordinarily, the manifolds in multicylinder compressors provide sufficient volume, but, in some cases, because of extraneous design influences, it will tend to be insufficient. The problem we are concerned with is the correct proportioning of a surge volume on, say, a small compressor, having on hand a satisfactory design in a similar, but larger, compressor. To make the example more concrete, let us assume that the small compressor has one fourth the capacity and twice the speed of the larger one.



'. . . . to work together in harmony.'

In the first place, our sense of proportion would lead us to make the cross-sectional area of the pipe line proportional to the capacity, thus obtaining the same average gas velocity in each case. However, we know from experimental work that this is not correct and we need a slightly greater proportion of area in the small compressor to keep the mean pressure drop in the line down to the same value as obtained in the larger machine. Specifically, in this case, the pipe diameter D_2 of the small compressor should bear the following relation to that of the larger, D_0

$$D_2 = D_0/\sqrt[5]{16} = 0.574\, D_0$$

Having done this, it would be natural, using one's sense of proportion, to make the surge volume for one cylinder proportional to the cylinder volume. For simplicity, we shall assume a single-cylinder compressor and consider the surge volume to be located in the cylinder head so that passages between a head and manifold are eliminated.

In a surge volume, the gas movements taking place are complicated from the analytical standpoint, but we know that, as gas is discharged into the chamber, the pressure will rise and start a flow of gas into and along the discharge line. Moreover, in the pipe line itself, a compression wave will form to

propagate the flow. If the pressure drop is small, as it should be, this wave will move at approximately the velocity of sound for the particular gas being compressed, which is about 500 fps in Freon-12, about 800 fps in sulphur dioxide, and 1100 fps in air. Now, at any given angular shaft speed, a definite time will elapse between the beginning and end of the discharge. In this time, the compression wave in the exhaust line of the large compressor will have progressed a definite distance, say L_1. Consequently, the total volume available for compression of the gas will be $V_t = V_h + A_1L_1$, where V_t = total volume, V_h = head or surge volume, A_1 = area of discharge line, and L_1 = distance of propagation in the exhaust period.

It should be clearly understood that the compression within this volume is not uniform but, in general, will be a maximum in or near the surge volume and zero at the wave front at the point L_1. It should further be understood that all of the gas discharged by the cylinder must have been forced into this volume and the resulting increase of pressure will bear some relation to the ratio of the discharged weight of gas to the weight that, on the average, is present in the available volume V_t. Without a study of the complicated hydrodynamics involved, it appears most reasonable to make the ratio of the discharged volume per stroke to the available volume V_t the same for each compressor.

Now let us see whether the ordinary proportioning will accomplish this. We will assume, to begin with, that the area of the smaller pipe line A_2 is $0.33A_1$, the correct area for the same average pressure drop. The smaller compressor, running at twice the speed and having one fourth the capacity of the larger one, will have one eighth of the displacement volume per cylinder.

Suppose that, on the large compressor, the head volume is equal to the cylinder volume, say 48 cu in., with a piston area of 12.2 sq in., and the pipe-line area is one eighth of the piston area. These are representative proportions. Suppose, further, that the speed is 900 rpm, the gas is Freon-12, and the conditions of operation are such that 60 deg of crank angle are required for discharge. Then, the time taken for discharge to be completed is 0.0111 sec, and, during this time, a compression wave in the pipe line could propagate itself a distance of 500 (0.0111) = 5.55 ft = 66.6 in. Consequently, the available volume is

$$V_t = 48 + 1/8\ (12.2)\ 66.6$$
$$= 149.5 \text{ cu in.}$$

In the small compressor, the piston displacement will be 48/8 = 6 cu in., its area 3.04 sq in., and the total volume needed is 149.5/8 = 18.7 cu in. Actually, using the same ratio of head volume and remembering that, since the speed is doubled, the discharge time is halved and the length of propagation is also halved, the volume will be

$$V_t = 6 + 0.33\ (1/8)\ 12.2\ (33.3) = 22.75 \text{ cu in.}$$

This, of course, is on the safe side. If we had taken the pipe-line area at exactly one fourth that of the larger machine, we should then have obtained exactly the 18.7 cu in. required. However, the former value is needed to prevent an excessive mean pressure drop.

Now, I seriously doubt if the average designer knowingly takes into account the velocity of sound when designing surge volumes and pipe lines, particularly in the field of compressor design. The really interesting revelation, though, is that nature seems so willing to arrange things so as to obviate the necessity of such painful thinking, requiring chiefly of the designer that he possess the artisan's intuitive sense of proportion, together, perhaps, with a sprinkling of ingenuity, and, if its a new job, some creative ability.

Not being quite old enough to have forgotten my sheepskin entirely, I cannot pass even this last noteworthy example of nature's amiable attitude toward the machine designer without pointing out one or two points where ordinary proportioning is apt to fail. In the first place, I think we can agree that one's sense of proportion would ordinarily proportion the pipe-line area to that of the piston and would tend to neglect the effect of diameter on the pressure drop at constant velocity. Also, there is frequently a relative difference in the lengths of pipe lines between small and large compressors, so that, in some cases, the length of line from the compressor to the condenser or storage tank is shorter than the distance of propagation in the discharge period, and this should be taken into account. (Incidentally, another place where sound velocity has a marked effect is in instruments designed for measuring the cylinder pressure for indicator cards. If the passages are too long, the readings may be several degrees out of phase with the true crank position, particularly in the high-speed compressors.)

Of course, there are numerous other examples in compressor design that could be cited if space and interest allowed. It is interesting, for example, to determine the manner in which clearance volume tends to vary with compressor speed. However, in practically every case that has come to my attention, the use of one's sense of proportion will yield results amazingly close to those indicated by the most detailed analysis. The exceptions usually arise when some particular phenomenon fails to present a geometric picture in the mind. It is in these cases that the designer needs the support of theory, preferably substantiated with test results. For example, several years ago, many designs of oil grooves in bearings were flagrantly in error, the grooves being commonly placed in the high-pressure regions of bearings, where they tended to induce failure.

Sometimes there is a geometric picture, but it involves the squares and cubes of distances, quantities which are not easily visualized in terms of the linear dimensions except after long experience. This can happen in balancing problems where products of inertia or perhaps centers of percussion are involved. Obviously, external linear proportion does not yield the proper result in these cases, but it is still possible to proportion such properties in the mind's eye if one has the essential definitions clearly visualized. As an example, I have found that, by utilizing the concept of radius of gyration and the fact that $I = MR^2$, I am enabled to estimate moments of inertia with reasonable accuracy.

To conclude, I think it is a fair summary of this subject to say that wherever a design involves geometric similitude, the designer's sense of proportion is of inestimable value, but that conversely, where geometry is not involved directly, the designer is apt to guess at the wrong answer unless he makes use of theory, or research, or both. Unfortunately, the highly technical man is only rarely endowed, to any high degree, with that combination of a fine sense of proportion, clarity of vision, and creative ability that is an attribute of the successful "practical" designer. Indeed, I fear, at times, that intensive technical training tends to becloud and suppress these desirable attributes, that too much logical thought tends to crowd out the more artistic and spontaneous creative thinking that is also necessary in design. Be that as it may, the modern design department is usually faced with the problem of providing both technical and so-called "practical" designers, and this in turn involves the problem of persuading these temperamentally different individuals to work together in harmony. The man is fortunate who possesses the talents for creative design and yet has a strong technical background.

WELDING *Applied to* PLANT MAINTENANCE *and* REPAIRS

By H. R. WASS

BONNE TERRE, MO.

WELDING as applied to plant maintenance and repairs is not a subject for brief investigation or superficial review; nor can the subject be exhaustively treated within the space here available. We must confine our discussion to a general consideration of the subject, offering specific examples of application in order to clarify the subject, as we see it, for the benefit of our readers.

In this discussion, we must omit reference to the atomic-hydrogen, carbon-arc, oxygen-hydrogen, and spot-and-seam resistance-welding methods, and the long-established and well-known thermit-welding processes. Their field of usefulness in maintenance and repair work appears rather limited, regardless of their intrinsic merit. We will refer only to the electric metallic-arc and the well-known oxyacetylene methods.

In general, the processes and practices appear well-established; based upon 1920 or even 1930 standards of practice, these methods have enabled the engineer to accomplish so much in the way of simplifying and improving his maintenance methods, reducing his repair costs, and fortifying his operating equipment for longer operating periods between major overhaul outages that no engineer can afford to overlook the opportunities which are virtually thrust into his line of vision by the use of these processes.

In using welding processes for maintenance and repair, the engineer will involuntarily use his imagination to expand the uses to include every conceivable maintenance application, and he will find himself, also involuntarily, applying the methods thus learned to alterations, and, eventually, to construction of new equipment and structures. We find it difficult, therefore, to establish any boundary lines or define any limitations as to maintenance or construction.

The engineer who has not used welding methods extensively and who is not fully familiar with the possibilities will encounter some definite obstacles. Just as many pitfalls await the experienced engineer who tries to do things that he should know better than to try.

Clay-working plants, lime and cement plants, mines and smelters, stone quarries, and similar industries offer complex problems in maintenance because of the diversity of equipment and construction materials. The same may be true of food-products plants, sugar refineries, breweries, distilleries, paper mills, textile plants, blast furnaces and steel plants, railroads, and public utilities. Each of these industries or processes has repair problems peculiar to the industry or plant; these specific problems may not be treated adequately in a generalized discussion.

REDESIGN FOR WELDING ELIMINATES UNSATISFACTORY REPAIRS

The proper procedure must be established in each case, often by the trial-and-error method. If a stable and successful repair is not practical or has too many outstanding limitations, you may, as many others have done, redesign the troublesome part, or possibly the whole machine, for construction by welding.

Definite and reliable design data covering welded-steel construction have been developed slowly; verifying the results and certifying the procedure have also been slow. As applied to maintenance and repair practices, few published data are available which will materially aid the engineer on specific problems. Such information, however, is gradually being accumulated and will, no doubt, eventually be available in handbook form.

Lack of reliable and infallible methods of readily testing the finished work has retarded the uses of the process, more especially when skilled operators were not available. The human equation is a prime factor in successful welding, just as much as in successful foundry molding, successful riveting in plate and structural fabrication, or proper placing of reinforcing steel in concrete. Successful welding, whether in construction or repair, must be done by skilled operators with intelligent supervision.

The maintenance man has neither time nor place for elaborate X-ray equipment, he has a limited budget and no skilled X-ray technicians available for the inspection of the finished job. Reviewing our experiences of the last 20 years, one answer is seen; that of thoroughly trained operators to whom your work may safely be intrusted.

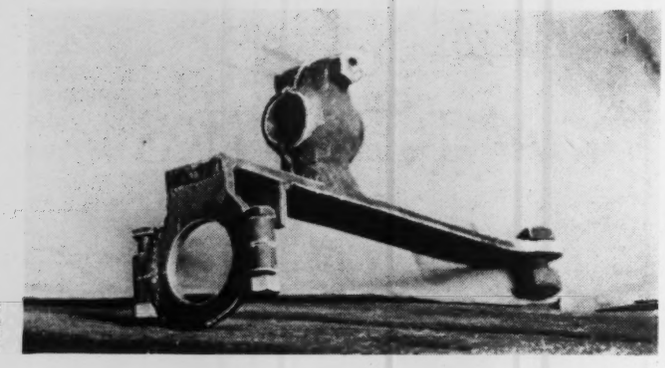
Repairs by welding, especially badly worn parts reclaimed by either the electric arc or the gas torch, have not always fulfilled our expectations and hopes. The failure of such a repaired part in service is not sufficient cause for condemning the process. Generally, some natural law has been innocently ignored or unconsciously violated; the cause of the failure may have been beyond control. Complete study will offer a solution.

Do not get excited about the low-cost possibilities of repairs by welding until you can take the time to investigate the process from all angles. You must have a firsthand knowledge of the metals you propose to work with, their make-up, characteristics, limitations, and possible behavior under welding conditions.

ALL-WELDED DIPPER HAS LONGER LIFE AND GREATER CAPACITY

Modern mining and quarrying require much heavy and ponderous machinery, which receives rough usage and abuse in service. Mechanical-handling equipment, such as power shovels, cars, and locomotives, and hoisting, conveying, and crushing equipment, all offer exceptional opportunities for applying fusion-welding methods to maintenance and repair. The dippers of the power shovels get the maximum of rough treatment and must be of unusually rugged construction. Our experiences indicate that an all-welded dipper consistently has double the life of an all-riveted one of equal capacity, each made up of rolled steel-plate and bar sections. The manganese-steel or chrome-nickel teeth are riveted to the body of the dipper in

Contributed by the Machine Shop Practice Division for presentation at the Semi-Annual Meeting, St. Louis, Mo., June 20–23, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.



ROCK-DRILL ATTACHMENT

each case. The life of the all-riveted dipper was doubled by the use of the arc and gas process in making field repairs. Loose rivets have lost all their annoying features because they can be welded to the base metals to tighten them. The rivetheads can be built up where worn and can be hard-faced to reduce further wear at these critical points. An all-welded dipper of the same weight cost 20 per cent less than a riveted one and had some 20 per cent more capacity. In addition to the doubled life, our conclusions favor the all-welded dipper. Use of the higher-strength steels, now available in rolled shapes, will reduce the gross weight further without loss of strength.

Alloy-steel dipper teeth of 14 per cent manganese steel, chrome-nickel steel, or other proprietary alloys show four and five times the original life when kept in shape and hard-faced with the metallic-arc process. Such treatment is sometimes a critical operation, as the grain structure of these alloys is sadly disturbed by welding heats recklessly applied. We make no attempt to weld such materials with the torch flame; in using the arc, concentrations of heat must be avoided, or the accumulated heat must be dissipated by absorption and possibly by water cooling. The chrome-nickel steels, where the chrome content is under 1 per cent, may be forged to shape either before or after welding, after which the quenching may be done. Manganese steel and the higher chrome alloys, 3 to 10 per cent of chrome, cannot be handled with too much care when welding. If properly done, the results will more than satisfy the most skeptical.

The life of tread drive sprockets and caterpillar shoes on tractors and self-propelled power shovels has been tripled in the same manner. Clay digging and handling machines are repaired in the same manner, and, while their usage is not so severe as with stone or ore-handling equipment, the results have been just as gratifying. Dump cars and locomotives generally handle twice the tonnage between major overhauls, because minor repairs can be made without taking the machine out of service for long.

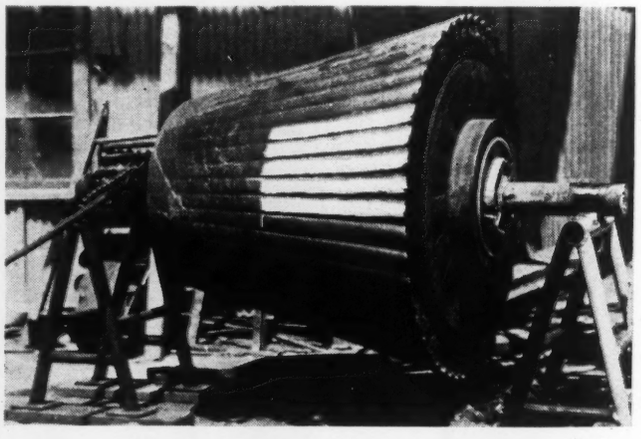
Major repairs to locomotives include broken main frames, which may be either welded with the arc or brazed with the gas torch and high-strength bronze filler metal. Either method requires proper preparation and procedure. The flanges on the main-driver tires, where worn thin, are built up in place; firebox tube sheets and side sheets are replaced; tubes are welded to the tube sheet; and wheel centers are built up for the tire fit and the axle fit. We do not feel justified in trying to reclaim old cast-iron wheel centers and have nothing in use but cast-steel parts. Driving axles are built up to size, annealed, and turned to fit for about 45 per cent of the cost of new axles. We might add that there have been no failures of welded parts in locomotive service. Driving boxes, shoes, wedges, and pedestal jaws of the main frame are reclaimed and kept in shape with the most useful and versatile of maintenance tools, the welder.

REPAIRING STONE-CRUSHER PARTS BY WELDING

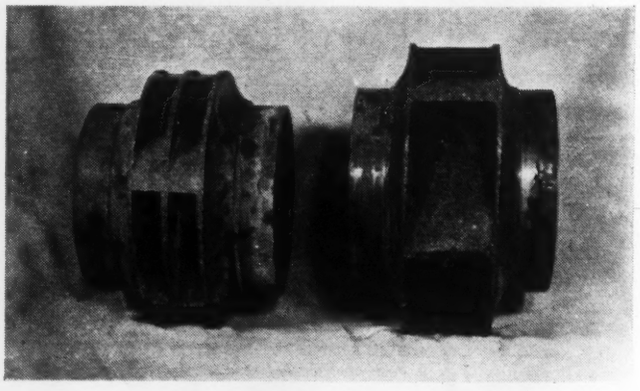
No machine, delicate or ponderous, is more sensitive to correct maintenance than stone crushers, particularly with regard to the shape and condition of the working faces which receive the greatest abrasive wear in service. These parts are generally made of manganese-steel castings, segmental and sectional in shape to permit handling and installing in place. When the crushing efficiency has decreased due to wear, these wearing surfaces must be restored by resetting, replacing outright, or building up with the arc, which latter is by far the quickest, least costly, and most satisfactory method of repairing.

Worn crushing faces not only decrease the capacity but the crushing efficiency of the machine. The saving in power in a short time would soon pay for a welding outfit.

In one case, where this method of maintaining the crushing faces was used, the repair and maintenance cost was reduced by 1 cent per ton of rock crushed. This saving of over $30 per working day would show up on anybody's cost sheet. When the process was first installed, several years' accumulation of discarded wearing parts were reclaimed. The cost of reclaiming was slightly under $3700, and the value, new, of



MANGANESE-STEEL CRUSHER HEAD FOR GYRATORY CRUSHER
(Weight, 17,800 lb. Built-up and hard-faced.)



WELDED PLATE STEEL IMPELLER (RIGHT) FOR CENTRIFUGAL CIRCULATING PUMP
(Original bronze impeller on left cost $283; welded-steel impeller cost $66.)

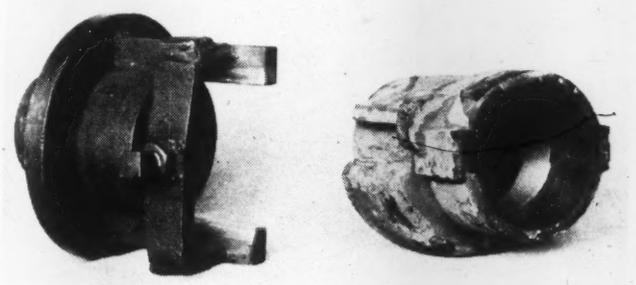
the reclaimed parts was just over $12,000. No such new parts have been purchased for the last 11 years, and future purchases are not contemplated.

Aside from the direct saving just mentioned, some experimenting was done in changing the shape and form of the crushing faces to determine whether or not such changes would or would not affect crushing efficiency and power consumption. These changes were considerably less costly than buying new castings which would require special pattern equipment and prolonged delays in delivery.

An investment of $7500 in welding machines and torches was responsible for savings of over $125,000 during a period of ten years on salvage and reclamation of discarded and unused or obsolete parts. On one job alone, a 300-amp welding generator refunded its entire cost in just 32 working hours, and, on the same job, a gas-cutting-and-welding outfit paid for itself in less than 24 hr. This generator, on routine repair work, makes possible daily savings equal to 1 per cent of its original cost; in other words, this outfit pays for itself three times a year. To evaluate the worth of the torch would be impossible; there are 78 torch outfits at work in this plant.

The gas-welding torches make their best showing on pipe welding and piping-system installations. Dismantling and salvaging unused but otherwise serviceable piping; erection of new systems, whether for gas, steam, compressed air, water, oil, ammonia, brine, acids, alkalies, or what not; altering old and existing systems; making special fittings as needed, such as

TREPANNING TOOL WITH CUTTING EDGES OF STELLITE
(Drills $5^7/_8$ in. diam.)



WELDED-STEEL LATHE CHUCK AND THE CASTING FINISHED IN THE CHUCK

LATHE CHUCKS FOR BOXING MOTOR BEARINGS

tees, bends, manifolds, long-sweep or double-sweep fittings, and fittings with side outlets in odd and strange locations. All these and as many more as the engineer can imagine, can, and should, be handled with the oxyacetylene torch. This statement is based on my own experience on such jobs; my preference for the gas torch is based upon its portability, its general suitability, and the over-all cost.

Forged welding fittings are available from several sources, they are of the same diameters, both inner and outer, as the commercial-weight pipe with which they are to be used. The angle of bend is correct, the tangents are ample, and the ends are ready to weld. Gate, globe, and check valves are on the market which have extension ends for permanent welding into the pipe lines and, when once installed, will not be always leaking at the joints, and will not require frequent gasket replacements. Pipe-line repairs, local pitting or corrosion, the replacement of a section of the pipe wall, or an entire section, may be accomplished quicker and cheaper than by any other method.

ENGINE AND MACHINERY REPAIRS

During the last ten years, I have been a party to the welding of several large machinery shafts, from 12 to 20 in. in diameter, worn undersize in the bearings; wheel and pulley fits; keyways; and similar parts. The cost of reclaiming such a shaft by welding, annealing, and machine finishing has been about 30 per cent of the cost of new shafts. Such material is not readily available in the market, and heroic measures must sometimes be resorted to. Several such shafts, 15 in. in diameter, were broken in service. Three of these, valued at about $1000 each, were repaired and placed back in service. One such break required over 400 lb of new metal to finish the job. The cost of gas welding this one shaft was twice that of repairing two other broken shafts with the arc. In each case, the cost was less than 40 per cent of the cost of a new shaft and the delivery was four weeks sooner. These repaired shafts have all been in service for about four years. The annealing and machine-finishing expense amounted to 20 per cent of the total cost.

A large cross-compound Corliss engine was earmarked for removal and the dismantling started by cutting the connecting rods each in three pieces, when more urgent work took precedence. A rather peculiar emergency arose, and the engine was ordered back into active service. The mutilated connecting rods were lined up, welded, annealed, straightened, and installed before the steam and condenser connections were ready. This engine ran with its rated load for 114 days without stopping.

The crank disk on a large horizontal gas engine became

loose on the crankshaft. While the bore in the disk was being trued up, the end of the crankshaft was built up with the arc welder and dressed to proper size with portable tool equipment. The gas torch heated the crank disk for making the shrink fit, and the crank was put into place. The unit was off the line for 51½ hr and has been in operation for six years since the repair was made.

Crushing rolls are used extensively in metal mining and in many other processes. The wear on the grinding faces is severe, and the former practice involved truing up the roll faces by turning off or grinding to secure a true face. This is now an obsolete practice, as the welder is used to put metal on instead of taking it off.

When the practice of building up was first started, several of these roll tires or shells were broken. This was a costly item and one that threatened the practice, until we learned how to build up the tires without breaking them. Once this was learned, we had no more trouble; moreover, all the broken tires were repaired by welding the break, which not only reclaimed these broken tires but also pointed out the way to postpone, for an indefinite period, the purchase of additional tires.

The same practices can be adapted in utility plants, cement plants, paper mills, or other lines of heavy manufacturing. The equipment is similar, and the engineer, being a person of initiative and imagination, will not willingly overlook any opportunity to better his equipment or his practices.

During the last few years, all of us have had to content ourselves with less than ever before. Even so small an item as a clay pick or a No. 2 dirt shovel responds to improvement by hard-facing the cutting edges, and, while the unit saving may be small, the aggregate may be great enough to consider seriously.

Generally maintenance forces are fully occupied, but whenever budgets permitted new construction, the plant forces handled the job wherever possible. In this connection, such items as storage bins, hoppers, ducts, elevator housings, and other production structures can, and in most cases should, be welded.

The economy of material and shop handling is such an important item of the installation expense that no engineer can afford to ignore or overlook any possibilities in this direction.

Elevator buckets have shown four and five times the usual life by hard-facing the lip and ends; screw conveyors have shown as much as eight times the life compared to the untreated metal.

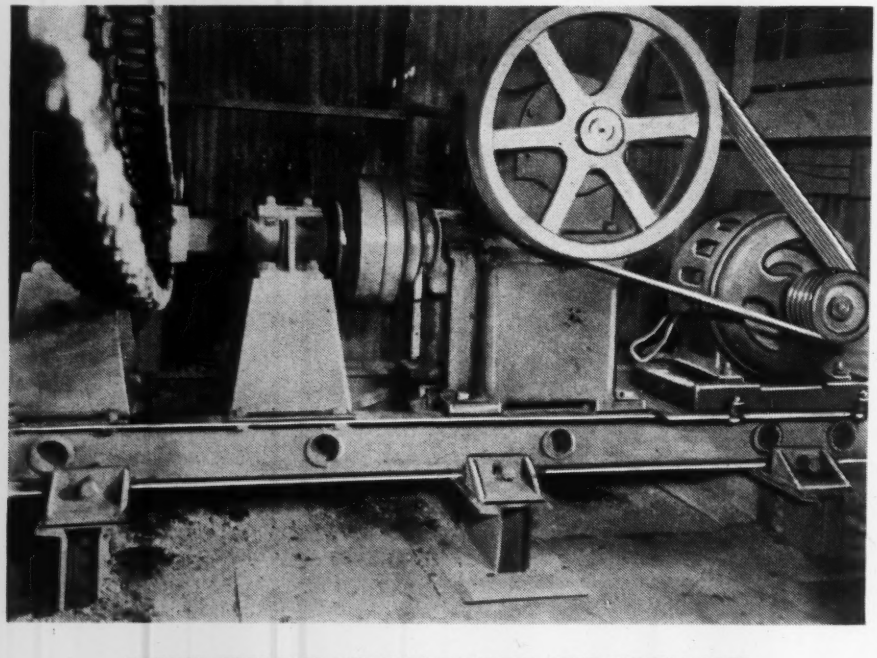
We do not advocate, as general practice, the repairing of steam-turbine blading by the use of the torch. It has been done successfully when no other way out was available, short of reblading. This calls for unusual skill on the part of the welder at best; it may also call for a tedious and tiresome job of rebalancing before the turbine runs right. The reclamation of brass or admiralty-metal condenser tubes by welding on new ends has also been successfully handled, with four leaky welds out of 460 tubes reclaimed.

Some years ago, the cast-iron impeller in a large centrifugal circulating pump failed. Delivery on a new impeller was four weeks, so a welded-steel impeller was built to replace the cast-iron failure. This steel impeller weighed 38 per cent less and cost 50 per cent less than the cast-iron one and increased the pump efficiency 8 per cent and the pump capacity about 20 per cent. It required five days to make and finish.

Metal-stamping and forging shops can profitably use hard-facing methods and materials on their various die equipment, and I recommend that the idea be studied thoroughly.

The recently developed metal-spraying process, while not as well known or as old as the fusion-welding method, has a definite place in modern maintenance practices, more especially in plants where corrosion is a factor. Investigation of this versatile process is earnestly recommended. The extent to which these processes can be profitably used in your own plant will depend on knowing your own costs for new materials and the cost of reclaiming or repairing old parts.

Wherever metal wears in service or wherever improvements can be made that lessen the sum total of human physical effort, it is essential that the engineer preserve the inherent tradition of his profession, by being first with the required remedy, which will, because of its favorable costs and effective results, insure him his rightful place in American industrial life.



WELDED STEEL BASE AND SLIDE RAILS FOR SPEED-REDUCER UNIT

Importance of MAINTENANCE *to* FOUNDRY OPERATION

By WILLIAM CARTER BLISS

SCULLIN STEEL COMPANY, ST. LOUIS, MO.

FOUNDRY methods, patterns, sands, and molds have changed little since the art of molding began, but the methods of making these molds, treating the sand before and after the metal is cast, and the handling of the castings themselves have developed rapidly with the mechanical age until maintenance of the various mechanical devices has become a problem upon which the production and costs depend. Not many years ago foundry methods were almost entirely manual. If a molder broke his shovel, he was given a new one at the storeroom, but the present demand for high-speed production has introduced problems that are far more complicated.

Foundry machinery in our plant, as in many others, must operate under very trying conditions 24 hours per day, making lubrication a problem. The ever-present sand, if permitted to mix with grease or oil, makes an excellent grinding compound, and every one knows the ultimate result. Hence, moving parts must be lubricated and, at the same time, protected to prevent excessive wear and the resulting high cost of maintenance.

The mechanical handling of sands, molds, and castings has created machinery that is complicated, expensive, and costly to maintain, and operating heads are constantly being faced with the danger of a breakdown that may tie up the shop and severely cripple production. Insurance companies cover plants for periods when production is stopped by fire, storms, or other causes. Breakdowns must be regarded in the same light, and money spent on spare parts, extra belts, and alternate machines considered as insurance against costly delays.

In an effort to produce castings quickly and at a *low* cost, perhaps we have gone too "mechanical," perhaps we have placed too many eggs in one basket. Undoubtedly, a happy medium exists beyond which it is certainly uneconomical to go. It is folly to install machinery to cut costs and then to spend money saved on maintenance.

Fortunately for the foundry, iron and steel are magnetic and the electric magnet plays a prominent part in production. The charge is loaded quickly and cheaply with a magnet that is adequately protected and economical to maintain. Magnetic pulleys play a prominent part, too, and save many dollars worth of chills, gaggers, fins, and spills by removing them from the sand.

The jolter, sand slinger, or other high-speed unit is the heart of the foundry and it is there that the highest efficiency must be maintained. Spare parts, extra fittings, valves, and bearings, and even a spare unit must be on hand in case of a breakdown. Every minute the unit is down means a loss in the shop. Spare parts which are used must be replaced immediately so that they will be on hand. A part that wears out quickly should be studied and, if possible, replaced with a more permanent piece. The unit must function perfectly; for an inferior mold is worse than no mold at all. Experienced trouble shooters should be on hand at all times and make frequent inspections to detect any wear that may give trouble later on. Catch a breakdown before it comes, and you will be money ahead. High-speed molding machines must be served if they are to pay. Do not install sand slingers, jolters, or other high-speed units without making provisions to supply the required amount of sand and also a shakeout to take care of the flasks and return them in time to the molding machines.

Contributed by the Iron and Steel Division for presentation at the Semi-Annual Meeting, St. Louis, Mo., June 20–23, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

SAND HANDLING

The question arises as to whether one sand system should be installed for all the units or one for each unit or pair of units. Both arrangements have their advantages and disadvantages. With a single system, a major breakdown stops production, while, with several units, production can continue at a reduced rate, until the necessary repairs are made. In slack times, one of the multiple units can be closed down with the resulting saving in power and wear and tear on the unit. One system must be run whether one molding machine or all are operating. The layout of the shop and the class of work handled will also determine the number of sand systems and units to use.

Sand must be elevated to supply a molding machine and two methods are in general use, an elevator and an inclined belt. We have both. For an elevator, it will pay in the long run to get the best-quality belt that money can buy. The belt carries a heavy load and may be subjected to severe strains. A broken belt means a costly delay, hours of hard work digging out the sand and restoring the belt to working order. For an inclined belt, our experience showed that troughing rolls are more desirable than side aprons. The latter must rub the belt to prevent loss of sand, and this point of contact wears the belt. Troughing rolls give the same results as side aprons without wearing the belt.

Sand mills are a necessary part of the sand system and present an acute problem in maintenance. The moving parts are constantly in contact with the sand, and proper lubrication is a problem. For a stationary pan and revolving mullers, a rugged and dependable center bearing is desirable. Our mills were supplied with bronze center bearings that lasted three weeks. They were replaced by roller and ball-thrust bearings that have been changed once in six years. Initial cost was higher, but the cost of repairs was reduced.

Flask shakeouts are necessary for high-speed units. The flasks must be shaken out after the castings have been removed to keep the molding-machine gang going. Air or mechanical shakeouts may be used. We feel that the latter are more efficient and easier to maintain. The sand from the shakeout is still appreciably warm and cannot be handled by a rubber belt. This necessitates a slow-moving apron conveyor consisting of pans connected by links and a sprocket drive. Shear pins must be provided to prevent excessive strains on the conveyor. The conveyor itself is difficult to lubricate properly and case-

hardened links have been tried in an effort to reduce the cost of maintenance.

The core room may be as mechanical as one cares to make it. A sand mill, of course, is necessary, with perhaps a skip hoist, a car for distributing the sand to the bins, core racks, and core trucks or a crane to handle racks to and from the ovens.

For a casting shakeout an air-driven hammer seems to be desirable. Castings are suspended in front of the hammer and are picked up and laid down by some form of movable hoist. The sand knocked out of the casting is removed by a belt that passes over a magnetic pulley. It may be reconditioned with the help of a vibrating screen, and used over again. The hammer and hoist are not costly to maintain, and, if proper care is taken, the belt and magnetic pulley will give months of service.

THE CLEANING ROOM

Cleaning-room operations consist chiefly of annealing, sandblasting, and chipping. An efficient toolroom that keeps the chipping hammers in first-class operating order is indispensable. The men will do better work, cut more pieces, and be better satisfied if they are provided with good hammers.

For the annealing furnace, insulation will show a material saving. I once heard the dean of open-hearth men say, "The time is coming when we must insulate to stay in business." I think his remark applies to annealing furnaces, core ovens, and dry-sand ovens as well. We have not taken the matter of insulation seriously enough. Insulation will reduce the quantity of fuel required and may be used over and over again in case of furnace or oven repairs. An insulated furnace will spall less and show a lower repair cost than one that is not. It is well worth the money invested.

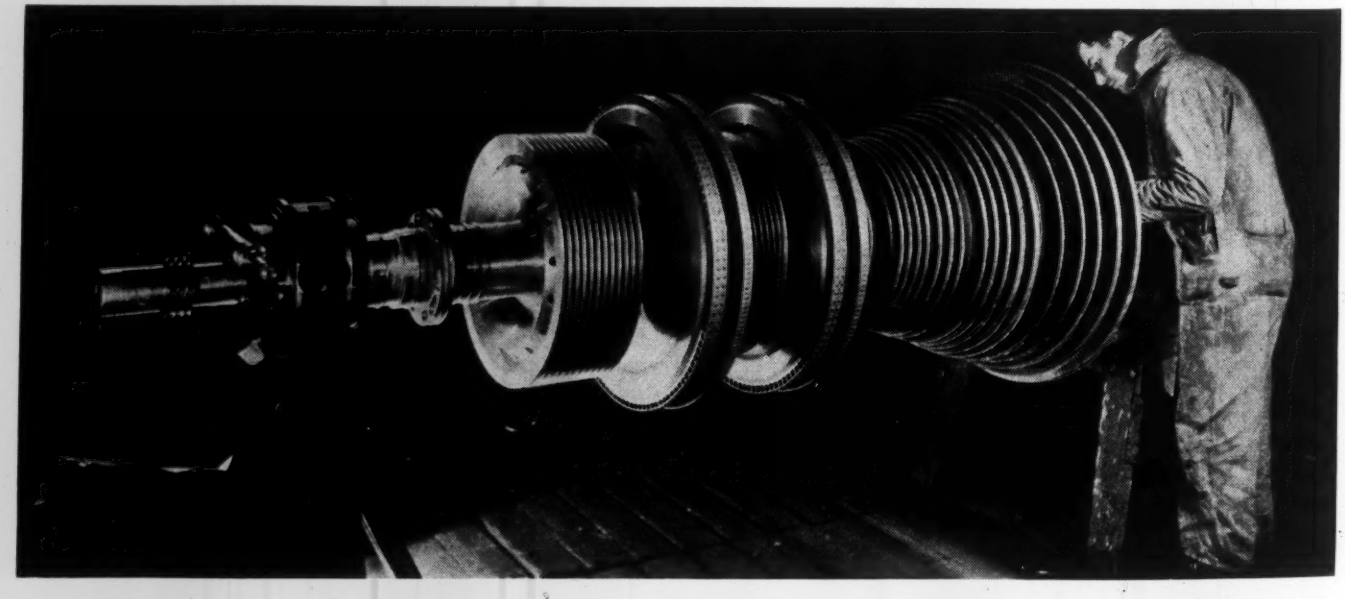
About one year ago we installed a sandblast that we believe is new in this district. The blast chamber is a long steel room that is open at both ends. The castings to be blown are suspended from a continuous chain and move past the operators who are on the outside of the room. Four stations, two on each side, are staggered and the operator looks at the work through a window. The nozzle is at the end of a pipe about four feet long which the operator controls with a handwheel. Dust collectors are provided for visibility only, and the operator works without respirator, goggles, or any protective device. We have blown side frames, bolsters, and yokes, and, with the proper rigging, miscellaneous castings may be blown. We feel that this blast is a decided step toward better working conditions for the sandblast operator. Proper illumination of a sandblast chamber is important. Lights must be placed to the best advantage and still be able to resist the abrasive action of the shot. The protective globes supplied us lasted about one week. Our final solution was to insert a steel box with a heavy glass in the wall of the chamber to the right and left of each operator. Light is supplied by a globe and reflector in the box which can be changed in a few minutes. We feel that this arrangement is the best suited for a sandblast installation. The inside of the chamber, which is subjected to blasting, will wear out and its protection is a problem that has not been solved satisfactorily. Old pieces of belting, loose chain, and even steel plates, which can be replaced, will cut down the repair bill on the blast.

PROVISIONS FOR REPAIRS, REPLACEMENTS, AND SAFETY

On a new installation, provisions must be made for the repairs or replacements that are bound to come. An I-beam should be installed directly over a motor for use when the armature is changed, and care should be exercised to avoid concrete walls that have to be chipped out before a part can be removed. A little forethought will save hours of costly delay and keep production up to standard.

When making a layout, the safety of the workmen should be kept in mind. Provisions should be made so that the trouble shooter can work safely. A costly accident has to be paid for out of profits and results in many hours of suffering that can be avoided.

In conclusion, I must not fail to mention one more essential, an efficient master mechanic. He must be a man who never gets excited, knows what to do when a breakdown occurs, always has a new part ready to replace the broken one, and seems to have the faculty of knowing where to look for trouble. The master-mechanic's job in a foundry is no bed of roses, and, after all is said and done, he plays an important part in the monthly costs of foundry operations.



STEAM-TURBINE ROTOR

(Modern steam-turbine rotor or spindle for a condensing bleeder-type machine rated 1500 kw assembled in the shops of the Allis-Chalmers Manufacturing Company. The turbine was designed for a pressure of 400 lb gage and bleeds steam at 150 lb gage.)

The TECHNIQUE *of* USING LANTERN SLIDES

By S. MARION TUCKER

POLYTECHNIC INSTITUTE OF BROOKLYN

JACKSON had prepared 50 lantern slides for his lecture on "Some Problems of Electric-Power Distribution." He had numbered them consecutively and carefully, with a guide tab at just the right corner, and had placed them in perfect order in the neat slide-holder box. Upon one unfortunate and unforgettable occasion long past, he had neglected to number his slides properly and to place them in right order, with disastrous and humiliating results that he yet recalled with a shudder in the still watches of the night. On the present occasion, however, all was well with his slides, and he had even been assured that the auditorium had a proper lantern, screen, and competent operator. Resting comfortably upon this assurance, he made no personal investigation of the conditions, reached the hall a few moments before his lecture was to begin, handed his box of slides to the operator, and took everything else for granted.

Yes, the lantern, screen, and operator were really there. But that misbegotten operator was far from competent. In spite of Jackson's careful arrangement of the slides, he managed to get several of them upside down; he had trouble in getting the right focus, he wasted time by his clumsiness, interrupted the continuity of the lecture, annoyed poor Jackson no end, and exasperated the audience. But the operator was not the only trouble; Jackson found that his pointer was far too short, only 18 in. instead of the several feet needed for him to reach any spot in the picture without stretching his arm and even part of his body in front of it. So often he was forced to obscure the very thing that he needed to illumine his statements. And he had to move from one side of the screen to the other, passing in front of it, of course, which not only temporarily blotted out much of the picture but also had an effect approaching the grotesque as witnessed with mingled amusement and annoyance by the audience.

It was altogether a scrappy and ineffective lecture, and yet it was largely Jackson's own fault. Like many other speakers, he had taken too much for granted. For the mere fact that an auditorium is supplied with a lantern, a screen, a pointer, a signal, and an operator does not in itself mean everything. One item or another may prove unsatisfactory, one thing or another may go wrong. When Jackson reflected about it afterward, he realized that he ought to have had some kind of rehearsal with that lantern and that operator. Perhaps, he could not have gone himself, but certainly he could have sent some trustworthy representative, with instructions, who could have had the operator try out the slides. Additional care, ahead of time, would have prevented all those ghastly blunders during the lecture.

Operator and lecturer should function as one person. A picture lecture is a mechanical thing; the speaker is, willy-nilly, subordinate to his pictures; and the mechanism should run so smoothly that the audience is not conscious of it at all. A speaker may have his own preferences about running that mechanism. Certain things may have to be done to suit his own particular needs on that particular occasion. How can an impersonal lantern, or even a human operator, know about this instinctively?

Hence, next time, Jackson will hold a rehearsal. He may say to the operator: "Sometimes, I don't want one picture to follow another immediately. I want a break between some of them. So when you hear the signal, remove the slide but don't put on the next slide until you get a second signal. And you see this slide, No. 27? It's a queer picture, out of focus itself and rather dim; so you'll have to change your focus temporarily to make it look like anything," and so on, but all ahead of time, so that the audience, which is all that counts, after all, will not be annoyed by mechanical inefficiency that could so easily have been avoided.

But, even at best, Jackson, among many others, finds a picture lecture hard and rather unremunerative to give. You might think it the easiest kind to give; the speaker has only to comment on his pictures, you say. But remember, he can scarcely see his audience, and his audience can scarcely see him. Contact is hard to maintain. Jackson, feeling handicapped by the comparative darkness, gets nervous and fidgety. Instead of standing quietly on one side of the screen, where he rightly belongs, and staying there, he strides from one side to the other, sometimes passing right in front of the picture itself. Deprived of visible gestures and of the changes in facial expression that he depends upon to reinforce his points when he can be seen by his audience, he flourishes his pointer as a drum major flourishes his baton, even when the pointer is not needed. His audience can dimly perceive his rapidly moving, gesticulating shape on the platform and finds its attention distracted from a mere voice explaining a picture by a gymnastic exhibition.

Jackson's bodily demonstrations were bad enough, but, at worst, they were only *physically* disturbing. He did not, as many speakers do, begin to talk about the next slide while the present one is still on the screen or continue to talk about the preceding one after another has followed it. When a speaker talks about a picture that has disappeared instead of the one that is staring the audience in the face and the one on which its attention is inevitably centered, he produces an intellectual confusion that is more confounding than all his possible inept physical movements. As regards the matter of comment on slide pictures, Sanderson, admirably adroit in his lecture mechanics, has worked out a few simple principles of procedure:

(1) When the audience is looking at a picture, it pays little attention to any comment that is not directly connected with that picture. Hence, if any preliminary statement needs to be made, it should be made *before* the picture is shown.

(2) The speaker should finish his discussion of any particular picture by the time that it disappears from the screen and then say nothing more about it, except what may be necessary to link it up with what follows.

(3) Similarly, the speaker should never actually begin to discuss a picture until it appears on the screen, except for some general preliminary statement such as that covered in (1).

(4) Leaving the screen blank occasionally is no objection. This gives the audience and the speaker an opportunity to look at each other. It also gives the speaker an opportunity to say something that he could not say so effectively were the audience looking at a picture.

(5) The prime thing to remember is that, when the audience is looking at a picture, *it is thinking of that picture*, and is mentally prepared to assimilate only what is strictly relevant to that picture. Hence, any other statement will be virtually wasted just at that time.

Fourth in a series of articles on the presentation of technical papers.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context, and credit to original sources is given.

Day by Day

IT MAY conceivably develop that the most important events of the past and recent months, in so far as they affect engineers engaged in industrial enterprises, are thoseconnected with labor relations. Certainly at meetings of The American Society of Mechanical Engineers a fair share of notice has been given to questions involving the attitude of the labor unions and to conditions faced by management in the administration of the Wagner Act. A decision of the Supreme Court in which the Secretary of Agriculture was severely criticized has resulted in a change of tactics on the part of the National Labor Relations Board in its handling of cases in which actions of corporations have been adjudged in violation of the Wagner Act. Although the legal and political phases of the struggle growing out of this act lie closest to the surface at present, it seems safe to record the present era as one in which the art of management is being put to one of its severest tests. All parties to this struggle are learning much that the less emotional approach of pure reason would never have taught. Not even in the economic chaos of the world-wide depression of the early 1930's has the industrial system, creature of engineering, been brought so vividly to the notice of the people as a whole. Only a confirmed pessimist would hold that no good will come out of it. It is part of a supreme test of industrialism and democracy, and the outcome is bound to affect the conditions under which mechanical engineers, particularly, practice their profession. In the meantime, the tempo of industrial progress is retarded, and, to many engineers, particularly those about to start their careers, immediate opportunities for profitable employment are far from bright. While waiting for this condition to mend, it is pleasant to read in the following notes of engineers whose achievements have been acclaimed, of progress in technology and industry, and of the growing consciousness in the engineering profession of its own importance.

Ford

Late in April a distinguished member of The American Society of Mechanical Engineers, Henry Ford, better known the world over, perhaps, than any other member, with the possible exception of Herbert Hoover, was front-page news because he lunched with the President. Less space was accorded the news that Mr. Ford had been named the second recipient of the James Watt International Medal, by the Institution of Mechanical Engineers—in fact a bare couple of inches sufficed for this dispatch from Great Britain.

In a pamphlet describing the medal it is noted that "to commemorate the bicentenary of the birth of James Watt . . . . . the Institution of Mechanical Engineers of Great Britain decided to award every two years a gold medal to an engineer of any nationality who is deemed worthy of the highest award the Institution can bestow and that a mechanical engineer can receive." It further stipulates that "the recipient himself should be an engineer who has achieved international recognition both by his work as a mechanical engineer and by the ability with which he had applied science to the progress of mechanical engineering."

Nominations for the second award of the medal, to be presented in January, 1939, were invited from some seventeen engineering societies throughout the world. In placing its nomination, The American Society of Mechanical Engineers directed attention to Mr. Ford's record and achievements which "place him in the forefront of American engineers who have contributed largely to the development of manufacturing methods during the present century, and to the production of an article of universal need at a cost and price to permit its purchase by hundreds of thousands of persons of limited financial resources. He was the first to make an automobile for the multitude."

The first recipient of the Watt medal, in 1937, was also a member of The American Society of Mechanical Engineers, Sir John A. F. Aspinall, railway engineer and administrator, who was elected to honorary membership in 1911. Sir John died on January 19, 1937, three days before the scheduled presentation of the medal.

Durand

A past-president and honorary member of The American Society of Mechanical Engineers, William F. Durand, has been awarded the Franklin Medal of The Franklin Institute "in recognition of his notable achievement as pioneer in laboratory research and theory of aerodynamics, and of his diversified and distinguished contributions to the science of hydrodynamics and aerodynamics, particularly to the advancement of the theory and development of aircraft propellers."

Dr. Durand has won so many honors that the list of them is too long to repeat. He fits perfectly the ideal specifications of a medalist. His lifetime of service to education, to science and engineering in research and practice, to learned societies, and to his country, has been filled with scholarly and professional activities that are still being vigorously pursued. With extraordinary personal charm, quiet modesty, and dignity, he graces every occasion in which he is a participant, and he can make a public address that is admired and applauded not only for its content but also for the admirable manner in which it is delivered.

Jewett

Among industrial research institutions the Bell Telephone Laboratories occupies an important place, and among the administrators of such institutions Dr. Frank B. Jewett, its president, is widely known. Hence the decision to confer on Dr.

Jewett the Washington Award for 1938 will be widely applauded by engineers. Presentation of the award was made on May 5, at the Palmer House, Chicago, at which time Dr. Jewett delivered an address entitled "The Engineer and Current Trends in Economic Thought." Representing The American Society of Mechanical Engineers on the occasion of the presentation of the award was W. L. Abbott, past-president of the Society.

Dr. Jewett's address was based upon a recent three months' tour of Egypt, Italy, Germany, and France, and particularly upon his observations on the place science and engineering occupy in the fascist countries. He had returned, he said, "more than ever convinced that democracy, with its necessary elements of spiritual and intellectual freedom, and, despite its creakings and groanings, is a far more substantial institution for operating the life of a great nation than anything offered by the glitter and trappings of a rigidly planned state."

As to the engineer's place and responsibility he said:

We engineers and scientists, whose training and experience has lain largely among the exact sciences, and who deal with problems capable of more or less quantitative solution, are, I think, likely to be irked rather than entertained by a subject which leaves so much latitude for speculation and display of individual preference as does that of the government of society. On the other hand, we cannot escape an increasing awareness of the fact that in recent years the world outside the totalitarian states is pointing a questioning if not an accusing finger at the engineering profession and its works. One of our present embarrassments lies in the fact that in the last decade it has suddenly and without real understanding of the scientific method, taken some of our protestations and arguments at more than their face value and has attempted to apply them wholesale far beyond the limits of possible successful operation.

Not only here in the United States but to a greater or less extent in every other country in the world, one of the most ghastly hoaxes imaginable has been perpetrated on society. I refer to the flood of social, economic, and political adventures which have been launched under the banner of "scientific experiments." . . . Almost without exception . . . . . the social and political sorties which have been staged under this stolen banner have been without scintilla of justification of what we of science and engineering understand as the scientific method. To us a scientific experiment is one which under controlled conditions can be repeated at will and in which but a single or at most a very limited number of unknown factors are involved. It is a method which is never used on a large scale before proven results are obtained on a small scale. It works successfully in our domain not only because of the controls which we impose but also because the things with which we deal are either inanimate or at least without conscious volition.

The charitable thing to say about those who have raised the banner of alleged scientific experimentation in the social and political sectors as justification for radical departures from the experience of the past is that they were ignorant of the fundamental postulates of scientific experimentation. . . . .

Citing certain comments by writers of today and a century ago, on the impact of science on society, he continued:

Our present difficulty, as I see it, is not that we scientists and engineers have produced too many things too fast, and that there should be a holiday in applied science, but rather that we, in common with the world at large, have failed to take seriously enough the matter of foreseeing and providing for the more important social consequences of our material achievements. If this is, as I believe it to be, a valid criticism of social action during the past one hundred and fifty years, then we of science and engineering, more possibly than most other groups, have something to account for. When, twenty-five or thirty years ago, I began to voice questionings of this kind and to argue for a broader conception of the engineer's function than I had been trained to, the answer which I received more commonly than not, even in educational institutions, was that the primary function of an engineer was to confine himself to the production and operation of the things of applied science, and let others worry about the social and political adjustments. I thought then, as I think now, that any argument along this line involves a fallacious assumption, namely, that nontechnical people, in addition to whatever competence they may have in their own fields, can be assumed to have as much competence about applied science instruments as those who create these instruments.

After saying this, let me hasten to add that I would not have you for a moment think me an advocate of turning over the operation of social or political matters to scientists or engineers. In my judgment, and speaking as one of the breed, I think that as a group, in which however there are many notable exceptions, we are probably less qualified than other groups to handle problems so far removed from the realm of controllable things with which we are accustomed to deal. All that I am trying to express is that we as scientists and engineers, both in our current functioning and in setting up the education of those who will follow us, should have a somewhat different concept of social responsibility than in the past. Further, that society generally, since it must continue to live with the things of applied science, will be well advised if it seeks seriously to find a way of enabling us to apply such talents as we may possess a bit beyond the realm of creating new instrumentalities.

Pointing to the misapplication of the scientific method by those not trained in its use as a danger which confronts us, Dr. Jewett remarked:

It is an axiom in science and engineering that what *can* be done in a laboratory *may* be done on a large scale—what *cannot* be done there *cannot* be done on a large scale.

Further, we know the amount of time which must elapse in the laboratory stage of any new development before practical application can safely be undertaken. We are prone to emphasize this and the multitude of difficulties to be overcome. Actually, both are great, but relative to the corresponding factors in social and economic problems they are few and simple.

Out of all this experience should come in the years ahead an enlarged opportunity to apply it in the social, economic, and political fields if in no other way than by influencing sincere men and women to avoid undertakings which in the very nature of things are doomed to failure because of the unknown or uncontrollable factors inherent in them. It is a challenge to us and likewise to our whole scheme of universal education.

One way out, he asserted, lies in "the education of the general population who are not to be practitioners in the field of science, but whose decisions control the current of its applications."

The problem is in essence a simple one although its solution is most difficult, both on account of sheer magnitude and because of past and present errors. It is the problem of indoctrinating the thinking part of the population with a modicum of better *real* understanding of science and its techniques—of its powers and limitations. All that is required is something sufficient to offset the superficial assumptions engendered by outward appearances and to impel men and women to seek advice from those in position to have it and to ponder this advice before action. . . . If I have learned one thing from forty years of struggle in science and engineering, it is not to expect to reach the promised land by lunch time or over a smooth highway unencumbered by traffic lights or detour signs. These may be irritating and cause us to arrive later than we hoped but they do insure a safe arrival for us and the children also.

Planck

The contributions to thermodynamics of Max Planck, who celebrated his eightieth birthday on April 23, are of such long standing that his name has become almost legendary to engineers. Better known, perhaps, to the world at large as the originator of the quantum theory, Planck has been a distinguished figure in the early development of modern physics. Writing in *Science*, April 22, 1938, E. C. Kemble says of him, "As the Copernican system gave the key to the heavens, so the

quantum theory of Planck has supplied the key to the submicroscopic world and to the understanding of the structure of matter." The first of his researches which led to the eventual overthrow of classical physics began about 1894. He was awarded the Nobel prize in physics in 1920.

Loree

Another famous contemporary figure, well known to engineers, celebrated his eightieth birthday on April 23—Leonor F. Loree, who retired recently as president of the Delaware and Hudson Company after 30 years of service in that capacity and 60 years of railroading. Probably no more picturesque personality exists in the railroad field in this country than Mr. Loree, who knows every department of that major industry and who kept alive its empire-building traditions. The story of the sale of his road's holdings in Wabash and Lehigh Valley stocks, clearing $23,000,000, and of his purchase, in 1929, for $10,000,000 of 500,000 shares of New York Central which would have cost $125,000,000 at the peak, was recently mentioned in the *Wall Street Journal* with a financial writer's enthusiasm for large transactions. To a relatively small group of engineers and industrialists, Mr. Loree is venerated as the admired founder, in 1923, of the American branch of the Newcomen Society for the study of the history of engineering and technology.

Budd

Pioneer in the recent developments of an important industrial art—the stamping of sheet metal—which began for him with the manufacture of steel pulleys and has resulted in the all-steel automobile body and the stainless-steel streamlined railway car—Edward G. Budd, president of the Edward G. Budd Manufacturing Co., Philadelphia, Pa., addressed the American branch of the Newcomen Society on May 5 on the subject "Genesis of an Art." C. E. Davies, secretary A.S.M.E., presided.

Lighter weight and greater durability have been the principal objectives in Mr. Budd's developments, and in seeking these he has provided a spur to progress in such collateral lines as rolling-mill practice, metallurgy, welding, press and die design, and the automobile and railway-car industries. How important his place will be in the resuscitation of the railroads, groggy with keen competition, the effects of a prolonged business depression, and the handicaps of burdening taxation and government regulation, only the future can properly assess, but to judge from the testimony of railroad executives who commented on the address, this place is assured.

The developments under Mr. Budd's supervision began with the steel pulley, quickly extended to the deeply drawn bowls of the cream separator, to the more difficult press job of the stamped artillery-wheel hub, to the substitution of steel stamping for castings in car seats, and to the first use of rolled steel in car bodies for the Pullman Company. Unable to find sheets of adequate size and finish among the products of the rolling mills, Mr. Budd turned to a fellow Philadelphian, Samuel Disston, who had produced large plates for circular saws. To Mr. Budd the rapid development of a technique that provided a steel plate 80 by 100 in., in no part of which did the thickest and thinnest parts differ by more than 0.002 in., was a miracle.

However, the development of the steel automobile body to replace the early wooden structures led to new and more spectacular results. Among these was the decision, a courageous one when the automobile was still considered a plaything by many, to enter this field. Presses grew from those measuring 36 in. between uprights to the modern triple-action mammoths 232 in. between the uprights, extending from 16 ft below floor level to 25 ft above, equipped with two downward and one upward working rams, and mounted with dies having within themselves sliding parts that give two or three additional movements successively with the rams.

Available sheets of 80 by 130 in. maximum dimensions were too small for the automobile body work undertaken and hence welding machines were developed to join narrow sheets in order to provide wide ones. But soon the spur of this demand called forth the continuous sheet mill in the steel industry and the early welding machines became unnecessary. Welding by the oxyacetylene process had early been resorted to by Budd in the manufacture of car seats. For certain jobs, spot welding was adopted, Morris Lachman being engaged to develop the shop process for Budd, and later, with the use of 18-8 steel in car bodies, "shot welding" extended the possibilities of the metal-joining arts.

Although 18-8 chrome-nickel alloy had been used for the manufacture of small stainless-steel parts, Mr. Budd seized upon its unique and valuable properties in his quest for lighter weight and greater durability, and boldly pioneered in applying it to large structures. The stainless-steel, light-weight, streamlined train, which first caught public fancy in the famous *Zephyr*, has demonstrated the brilliance of this idea of using the new metal for large structures, and provided an opportunity to introduce unconventional design and structural features in the well-standardized field of railway cars.

Mr. Budd modestly paid tribute to a host of others, including his own associates, whose work contributed to his own achievements. "The president of such an organization," he said, "can well be proud of the product, but how much more proud and how dependent he necessarily feels toward the group that produces the product?"

Biological Engineering

Some years ago readers of MECHANICAL ENGINEERING were introduced to a fairly recent development in surgery known as biomechanics, through an article in which the author, Dr. Chas. Murray Gratz, explained how his technique had been assisted and developed by cooperation with mechanical engineers expert in the testing of materials. Further evidence of the contributions engineering can make to the biological sciences was adduced by Karl T. Compton, president, Massachusetts Institute of Technology, member, A.S.M.E., in an address, "Possibilities in Biological Engineering," delivered on April 6, 1938, before The American College of Physicians, in New York City.

After citing examples of the liaison already effected in many instances between biology and engineering, Dr. Compton puts forward the opinion that, in order to expedite this development, young scientists should receive parallel training in biology, physics, and chemistry. He recalled the new type of training for young men preparing for the chemical-manufacturing industry in which there is a concentration on a limited number of processes and operations basic to all chemical manufacture which give a thorough grasp of the processes from the physical, chemical, and mathematical viewpoints, all built on thorough groundwork in these basic sciences. "Just as systematic applications of physics and mechanical engineering to chemistry produced a useful art of chemical engineering," he said, "so a systematic application to biology of physics, chemistry, and electrical engineering may create a useful art of biological engineering."

In Dr. Compton's opinion, the three essentials for the de-

velopment of biological engineering are an educational program, a research program, and an organization. Applying the "unit process" analogy to the educational program, he listed available concepts, tools, techniques, and opportunities by mentioning numerous types of energy, ways in which these types of energy are likely to be involved, the construction and operation of devices for objective measurement of the energy changes, the technical skills useful in constructing experimental and recording apparatus, and the fields of usefulness in which biological engineers may become engaged.

The educational curriculum which will provide knowledge of biology and at the same time training in the principles and techniques of the cooperating sciences "should recognize first, that the field is too broad to be handled in an introductory manner, in a four-year college course, and second, that education along these various lines should proceed more or less in parallel rather than ad seriatim." There was then outlined briefly the five-year course at M.I.T.

The research program should proceed side by side with the educational program, and to illustrate the character of such a program Dr. Compton described some of the work being carried on at his institution. As to organization, he said, a department of biological engineering should be headed by a biologist, and should include a physicist, an organic chemist, an analytical chemist, and an electrical engineer, and there should coexist departments in the scientific and engineering fields whose members can be drawn in for consultation and temporary help. To these must be added a cooperating medical group to handle the medical aspects deriving from the program.

Steel Decade

One valuable result of the lean years of depression has been an improvement in the quality of corporation reports. Numerous examples have been noted recently in the public press; and among outstanding features has been a sincere attempt to give the public, and particularly the corporation's employees, a better understanding of the problems with which management must cope. Of such reports, that of Myron C. Taylor, recently retired chairman of the board of directors, United States Steel Corporation, is an example.

Mr. Taylor's report includes a ten-year résumé of the Steel Corporation's history—a period during which at no time "have conditions been what could be called normal—no matter how the meaning of that word may be stretched." In 1928, for example the corporation operated at 83.4 per cent of finished-steel capacity, and in the following years up to and including 1936, the percentages were, respectively, 89.2, 65.6, 38, 18.3, 28.7, 31.2, 38.8, 59.3. Then, in April, 1937, came a high of 90.9, and in December of the same year a low of 30.2, the average for 1937 being 71.2 per cent. As Mr. Taylor pointed out, we have not been a self-supporting nation since 1931, the year federal deficits began, and, probably as a result, the character of steel consumption changed as the country moved from a capital-goods economy to a consumption economy. Moreover, the industry itself went through a revolution in the introduction of continuous rolling mills for the production of flat hot- and cold-rolled products. Said Mr. Taylor, "The Steel Corporation of today is not the Steel Corporation of 1928. Its financial economy has been made over, its directing personnel and the manner of its direction have been made over, and its physical properties have been so largely made over, that, of the production in 1937, scarcely one quarter was of the same composition or made in the same fashion as the production of 1928."

In his report of a ten-year stewardship Mr. Taylor reviewed the important changes, including those in the science of steel-making, the abandonment of obsolete or unnecessary plants with an annual finished-product capacity of 1,700,000 tons and an ingot capacity of 2,225,000 gross tons, the new mills built, and financial and personnel reorganization. As to research, he reported that at the close of 1937 the corporation had 174 laboratory departments and that, in 1937, metallurgy and research cost $8,400,000.

A considerable portion of the report was devoted to the labor problem. The first dozen years of the Corporation, he said, covered the change from handcraft to machine production, while the last ten years had seen the advent of a more complete mechanization. Although mechanization produced changes in the character of jobs and rates of pay, the effect had been to revise rates of pay upward. Also, it was demonstrated in 1937 that, with anything like a normal demand for iron and steel, production will increase at a rate to require additional employees at least at the rate of increase of the working population.

As to provision for "new blood" in the industry, Mr. Taylor said:

"Recognizing a threatened future shortage in skilled workers and also recognizing that many high-school graduates have no opportunity to acquire a skill which would enable them to earn higher wages, we have brought into being in the Carnegie-Illinois Corporation what we call a plan for apprentice training but which is really in the nature of an industrial university. The boys, who must be at least eighteen years of age and of good character, are given a thorough mechanical training in the shops and mills and at the same time are taught mathematics, mechanics, and the strength of materials, with specialized technical instruction according to the subject on which the student chooses to concentrate. The boys are paid at nearly the same rate as common labor and hence no boy need, for the lack of funds, give up the opportunity to qualify himself for the higher pay ranges and the eventual chance of becoming an executive. Most of the Corporation's executives began in the ranks and without the advantage of such training. We fervently desire to keep open the way from the bottom to the top."

Conservation

Addressing the annual "round up" of the Nebraska Engineering Society at Omaha, Neb., April 2, 1938, John C. Page, Commissioner of Reclamation, asserted that "the times cry loudly for the engineer with a social conscience, both in the service of the government and in private practice."

"We are in a new day which opens many broad opportunities to the engineer," he said, "but before he can seize them he must be an engineer plus. He must be an engineer as adept as ever with his slide rule, his transit, and blueprints, but he needs additional qualifications of leadership and broad social knowledge to assume the place which may be his in this new era which will emphasize conservation."

Much of the work of the Bureau of Reclamation is engineering, he explained, as indicated by the fact that "we have constructed 138 dams, and we are now building a score more and that we have built about 20,000 miles of canals . . . . . We have made homes for almost 900,000 persons on 48,773 farms and in 257 towns and cities by the irrigation of about 3,000,000 acres of land in projects scattered throughout the arid West . . . . Since this work began in 1902, crops valued at nearly 2½ billions of dollars, or more than ten times the cost of the irrigation works of the projects which now are being operated, have been harvested and marketed by the farmers in these irrigated

areas . . . . . Of 700,000,000 acres in the arid and semiarid West, 20,000,000 acres are now developed by irrigation. It is estimated that the remaining unused water resources will irrigate only an additional 10,000,000 acres with projects which can be considered feasible at the present time. Projects now under construction by the Bureau of Reclamation will bring in, on their completion, about one quarter of the remaining feasibly irrigable lands. The selection of the lands which are to be developed in the future is a serious matter."

Publicity

On page 461 of this issue brief comment will be found on the Engineering Public Relations Committee (Great Britain) and its recent pamphlet "Engineering: What It Is and Does." In The *Engineer* for April 8 is a note on the report of this committee for the year ended March 31, 1938. The committee was formed as the result of a joint meeting of leading institutions held in December, 1936, and its first meeting took place on April 27, 1937. Fourteen professional engineering societies are cooperating in the work of the committee whose object is "to disseminate knowledge for the general advancement of engineering science by presenting to the public in suitable form information concerning the science and practice of engineering and its services to the public."

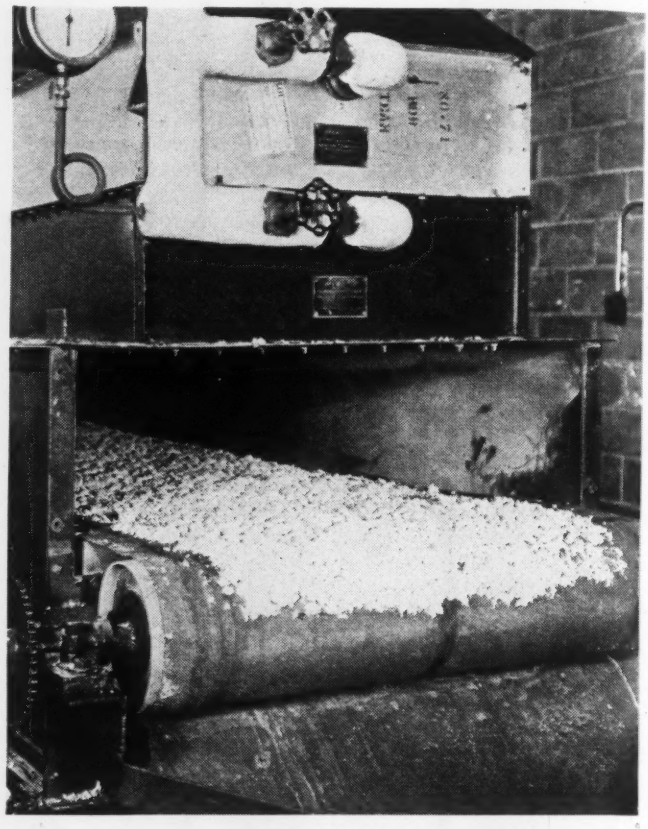
During the past year the committee held several sessions and its executive committee announced a program of work, at a luncheon on Jan. 6, 1938. Since that luncheon various lectures have been given at institutions and schools, and the pamphlet referred to has been issued. A film library has been started, seven films have been presented, and others promised, while eight sets of lantern slides to illustrate lectures have been arranged. Contacts have also been established with the British Film Institute, the National Publicity Committee under the chief diplomatic adviser to the Foreign Office, and the British Broadcasting Corporation.

Rubber

In this section of the February issue was abstracted an article on synthetic rubber which contained a brief description of the development of the better known forms of this material and their properties. Manufacture of one of these products, Thiokol, according to a recent announcement, has been undertaken by the Dow Chemical Company in a new plant, opened in May, at Midland, Mich., with a capacity of 2,000,000 lb annually, sufficient for the fabrication of about 3000 tons of finished products. It is said that the Thiokol Corporation of Trenton, N. J., will concentrate its efforts on research, sales, and product development.

Involved in the manufacture of this synthetic rubber are three basic steps: Preparation of a polysulphide, reaction between this and ethylene dichloride to form synthetic rubber latex, and coagulation of the latex into rubber crumbs. At the new plant the processes are completely mechanized, and the accompanying illustration shows the crumbs of dried coagulated product coming off the continuous belt at the end of the drier.

Resistance to the effects of petroleum, certain solvents and chemicals, sunlight, air, and moisture, in addition to the familiar properties of natural rubber, is claimed for the synthetic product. At present the product is available in several forms and seven grades, including crude rubber, liquid coating materials, printing-plate powders, and molding powders. Crude synthetic rubber is fabricated by the methods employed with natural rubber, and powdered forms are converted into finished products by thermoplastic molding. Costs relative to natural rubber are not mentioned.



COAGULATED SYNTHETIC RUBBER COMING OFF CONTINUOUS BELT AT END OF DRIER

Transoceanic Flying

AIR COMMERCE BULLETIN

THAT the United States Department of Commerce is resolved "that America's place in world air commerce shall be second to none," was announced by Col. J. Monroe Johnson, assistant secretary of commerce, in an address before the Providence Engineering Society, March 24, 1938, published in the April 15 issue of *Air Commerce Bulletin*.

Calling attention to American achievement in transoceanic flying, Col. Johnson said that for several years regularly scheduled flights have been made across the Caribbean, and 18 months ago this continent was linked with Asia. During the first year of operation almost 2000 persons were carried across the Pacific, and over this same route the clipper ships have transported 37 tons of mail and 500,000 lb of freight and express.

For ten years, he continued, plans have been projected for a transatlantic service, in which the chief obstacle to overcome is the weather. Aircraft to cope with this natural hazard have been produced by Sikorsky, Martin, Boeing, and Consolidated. The Consolidated flying boat now being tested, he said, has a gross weight of 60,000 pounds, is powered with four engines, and has a range of almost 5000 miles with an 8000-lb pay load. The new Boeing 314 ordered by Pan American Airways for the transatlantic service will soon be ready for its tests, he an-

nounced. The Boeing flying boat will accommodate 72 passengers on day flights, and a crew of 8. It will provide berths for 40 overnight passengers, with additional space for 5000 lb of mail, and should have a cruising range of almost 5000 miles at 200 mph. They will be the first flying boats to contain two full decks, and will provide the highest degree of passenger comfort for the long ocean flights. Problems of landing rights on mid-Atlantic possessions of foreign governments seem facile in their solution with such flying range, for the trip can be made nonstop from continental United States to Europe. Then why not land planes? Perhaps that is the answer, he said, but today few landing areas and runways are of sufficient size to permit the operation of such large aircraft.

Speaking of efforts by foreign lines, Col. Johnson said that the French and Germans have been transporting mail and express across the South Atlantic, gaining valuable transoceanic flying experience. The ill-fated *Hindenburg* completed 10 round trips between Friedrichshafen and Lakehurst in 1936 and expected to make 18 such schedules last year. Permission already has been granted for landing privileges for a new and larger helium-filled lighter-than-air ship, LZ-130, and Germany has announced her intention of again operating a regular transatlantic service. Last summer the Imperial Airways and Pan American Airways each completed three round-trip crossings—two across the North Atlantic and one by way of Bermuda and the Azores, and Deutsche Lufthansa catapulted the *Nordmeer* on its way to New York. Unexpected delays prevented the French from making their projected survey flights, but all is in readiness for an early crossing.

Numerous experiments are being conducted with heavier-than-air craft. The Germans have been working on a "flying wing" for several years. The twin-float, 4-motored seaplane used in their survey flights is of radical design and the heaviest aircraft ever designed for catapult launchings. It has a cruising range of 3100 miles at 156 mph. England's new Empire flying boats, composite aircraft and 4-motored land planes, are designed to permit the take-off of heavily loaded airplanes that will be launched in flight. French aircraft designers and manufacturers offer the fastest large flying boats in service, with a cruising speed of 200 mph. A new and larger Leo, which is expected to be ready for service in two years, will carry 40 passengers and 4400 pounds of mail and freight and cruise 20 hours nonstop. And plans are drawn for the huge 76-passenger, 37-ton, 6-engined Latecoere flying boat

Flying at 30,000 Feet

JOURNAL OF THE AERONAUTICAL SCIENCES

REGULAR transport operation of airplanes at 30,000- to 35,000-ft levels will come within the next ten years, according to a paper presented by D. W. Tomlinson at the 1937 annual meeting of the A.A.A.S. and published in the *Journal of the Aeronautical Sciences*, February, 1938. Describing a series of 33 experimental flights at these altitudes made by him in a Northrop Gamma airplane during the past three years, Tomlinson predicts from his observations of conditions at the base of the stratosphere that, after more study, it will play an important part in long-range, nonstop flying.

The principal objectives of the experiments were: (1) To choose the best method of supercharging to 20,000 ft and above and equip an engine for rated power operation at 30,000 ft; (2) to determine the actual increase of speed with altitude as a check against theory; (3) to make actual measurements of speed at 30,000 ft further to check computed true air speeds; and (4) to make extended cross-country flights "over weather" to determine force and direction of winds and meteorological conditions at the base of the stratosphere. The first three objectives have been accomplished. Regarding the fourth objective, the author says that perfection of the meteorograph and extensive data from additional flights over many storm conditions must be had before any useful and comprehensive conclusion can be reached about weather and winds on top of storm areas.

Choice of a supercharging method lay between the gear-driven impeller and the exhaust-turbine types. Whereas the gear-driven supercharger reaches maximum efficiency at only one cruising altitude, the turbine supercharger is sufficiently flexible in its operation to enable a pilot flying above the critical cruising altitude to utilize it as desired when cruising at full engine throttle. In this case the engine power diverted to supercharging is limited to that actually required above the energy recaptured from the exhaust gases.

The oxygen equipment in the cabin consisted of a 15-liter bottle of liquid oxygen with a vaporizing coil heated by hot air from the intensifier tube in the exhaust manifold and two lightweight gaseous-oxygen bottles of 39 cu ft capacity each. The practice was to use gaseous oxygen for flights of less than two hours' duration, and, as an emergency supply, to supplement with liquid oxygen; for longer flights the liquid oxygen was used. By boosting the pressure in the liquid-oxygen bottle to 15 lb prior to take-off, adequate evaporated oxygen supply would be available in ten minutes. On several occasions when cruising at 35,000 ft, it was found necessary to cut in the gaseous oxygen from time to time to insure an adequate supply, inasmuch as at these levels the crew had to breathe pure oxygen. Also during rapid descents from high altitudes, gaseous oxygen was used when, due to increase in atmospheric pressure, the evaporation rate of the liquid oxygen markedly decreased and the output of the vaporizing coils was no longer sufficient to supply the needs of the pilot and observer.

It was found that complete loss of the oxygen supply at 30,000 ft produced great mental and physical inefficiency in from 30 to 60 sec, and caused complete unconsciousness in 60 to 90 sec. Prolonged moderate or severe oxygen want for a relatively short period caused mental retardation and confusion for 30 min or longer after the oxygen want had been relieved.

The experiments proved the seriousness of the fuel-supply problem in the stratosphere. Not only is the matter of fuel pressure difficult but also the matter of evaporation is a question of unknown proportions. It is definitely known that fuel pumps must be completely drowned, located in the bottom of the fuel tanks, and driven electrically or hydraulically. Evaporation losses were not observed during the flights and therefore figures are not available. However, as such loss is inescapable with present fuels, it will be necessary, before extensive operating is done at stratospheric levels, to develop a less volatile fuel, or to put the fuel tanks and the cabin under pressure, even though pressure in fuel tanks is definitely undesirable.

Spark-plug trouble, evidenced by engine roughness, was observed above 25,000 ft. During a series of test flights made in collaboration with the U. S. Army at Wright Field, plugs were removed, tested, and new ones installed prior to flights. It was conclusively determined that plugs were breaking down between 25,000 and 30,000 ft under full-power operation. Better spark plugs than any now available will be required to insure satisfactory operation and life at altitudes above 25,000 ft. A magneto was found to be dead after a climb to 35,500 ft. This failure was caused by the high-tension circuit arcing across from the high-tension outlet to the ground. No difficulty of any kind was encountered from the shielded-ignition harness.

To answer the question which has been raised frequently re-

garding the reliability of air-speed meter readings at high altitudes, the air-speed meter was carefully calibrated and several flights made at 30,000 ft around a triangular course. The turning points were the cones of silence above U. S. Department of Commerce radio-range stations located at Kansas City, Kirksville, and Columbia, Mo., the lengths of the legs being 128, 78½, and 120½ miles, respectively. From the results of several flights, it was found that the level speed curve of true air speeds at 500 hp shows speeds of 165 mph at sea level and 225 mph at 30,000 ft. This is an increase of 36.4 per cent, which compares with the theoretical maximum of 38 per cent.

During the flights, the moment the plane touched high cirrus clouds, heavy static was heard in the radio. On a flight to Dayton, Ohio, from Kansas City, the plane, in descending to land, entered a cloud at 30,000 ft and reached its bottom at 8000 ft; 22,000 ft of absolutely continuous cloud. This particular cloud was also different in that it appeared to be a moderate mist instead of having the fog-like aspect of the normal cloud. Also the instant the plane touched the cloud, all radio reception was ended because of heavy static. On a flight to New York, the author's opinion, shared by many others, that storm clouds (thunderheads excepted) did not extend above 30,000 ft was completely altered when he got lost in a storm, the top of which was estimated at 40,000 ft and the area covered by it extended from the Mississippi River to beyond the Atlantic seaboard. Strangely enough, throughout the flight, the air above 30,000 ft was as "smooth as glass." Today such clouds should not offer any difficulty to high-altitude flying provided planes are equipped with shielded antistatic radio antennas.

As a conclusion to his paper, Tomlinson proposes that the meager knowledge of conditions at the base of the atmosphere be expanded by the Government with the establishment of a special department of the U. S. Weather Bureau. About fifty U. S. Army planes equipped with turbine superchargers, soon to be obsolete from the military standpoint but still suitable and satisfactory for high-altitude flights, could be made available for the use of this proposed department. In conjunction with this service, a large number of meteorograph stations should be established to augment the data obtained from the airplane flights. Further, it is proposed that Congress grant an appropriation for the development of an experimental high-altitude, high-speed transcontinental air-mail service with planes cruising at 30,000 ft and making not more than one stop. This scheduled operation would provide a proving ground for all the mechanical devices essential for high-altitude flying, including pressure cabins, and pave the way for the passenger transports.

Graphite Films

ENGINEERING

ALTHOUGH dry graphite has no tendency to adhere to many metal surfaces, A. H. Stuart, in an article "Industrial Applications of the Physical Properties of Graphite," *Engineering*, March 11, 1938, reports the remarkable adhesive property of a solution containing colloidal graphite suspended in water, Aquadag. A stock solution is made containing 1 per cent gelatine and 0.01 per cent potassium bichromate. For many purposes, it is said, it is convenient to take one part of this added to one part of Aquadag and two parts of distilled water. Such a mixture would contain colloidal graphite 4.5 per cent, gelatine 0.25 per cent, and potassium bichromate 0.0025 per cent.

This mixture, applied with a soft brush, will adhere when dry to almost any hard surface that is not greasy. The author states that he prepared a piece of glass by rubbing it with a cloth, gave it one coat of the mixture, and, after drying, boiled it in water, removed it, and plunged it in cold water. At no place did the film separate from the glass. It is said that application has been made for a patent for the mixture.

Among several other successful trials of the material, the following are quoted from the article:

1 The coating prevented sticking of lead to a steel rod that was dipped in and out of a bath of molten lead while the temperature was raised until the steel became red hot. On cooling the graphite film was found to be uninjured.

2 The coating prevented adhesion to an electric immersion heater of scale customarily formed when the uncoated heater was used in hard water.

3 As a lubricant the coating was used on foodstuffs-machinery bearings where oil would have been objectionable.

4 The coating lubricated knife blades of electric circuit breakers where oil could not be used.

5 Small parts, such as hinge pins, may be provided with a lasting lubricant on assembly by one application of the mixture.

6 Applied to glass, mica, or paper, electrical resistances may be made for wireless components. Variations in resistance due to humidity do not occur when mica is used because the film has no hygroscopic properties.

7 Applied to wood or plastics of the Bakelite type, the mixture produces a surface sufficiently electrically conducting to be electroplated.

8 Bolts and studs exposed to the weather or to the corrosive influence of hot flue gases may be protected so that, after weeks of such exposure, the threads come apart without effort.

Laminated Plastic Wood

MODERN PLASTICS

RIGHT DOWN the street from A.S.M.E. headquarters is the new F. W. Woolworth Fifth Avenue store which is decorated throughout its basement and two upper selling floors with panels of various kinds of wood treated with a phenolic solution. A brief description of this latest development in the plastic world is hereby given, being taken from an article appearing in *Modern Plastics*, April, 1938.

Thin veneers of genuine wood, treated with a resinous binder and vulcanized into sheets, come through with a surface that is smoother, more uniform, and clearer than it is possible to attain by applying varnish or lacquer to wood either by brush or spray. While the color and detail of the grain are not changed in the least by this process, the wood acquires a lasting finish that is wear-resisting and not affected by ordinary liquids. Made up in a special grade for use on table and counter tops, the material is said to be safe from burns and scorches caused by cigarettes.

The laminated sheets into which the wood is incorporated are but one sixteenth of an inch thick and the maximum size of each sheet is 3 ft by 8 ft. When used for wall paneling, column covering, or table and counter tops, the plastic sheet must be attached to a plywood back, which operation is accomplished on a veneer press. Once mounted, various panels or sections can be spliced together making an invisible joining and handled in much the same manner as any other piece of wood, except that all finishing has been done before the material is delivered for installation.

Not all woods can be processed in this way, but those avail-

able are sufficient to provide the architect and designer with a wide range of grains suitable for innumerable applications. Among them are flat-cut, figured flat-cut, quartered, half-round, and claro walnut; flat-cut, ribbon, and figured primavera wood; flat-cut and ribbon mahogany; figured red gum; lacewood; macawood; sapeli; plain and figured teak; figured aspen; zebrawood; satin wood; English oak; African cherry; gray harewood; and Macassar ebony. At the time of processing, any of these may be inlaid with metal or strips of contrasting wood according to the architect's specifications so that a minimum of fitting is required when the material is set in place.

A Novel French Airplane Engine

FLIGHT

THE LATEST in unorthodox engine designs includes an ingenious plan for coupling up several small engines of normal design and arranging them in the most suitable form for installation in a small high-powered warplane with a shell-gun as part of its armament. The supercharged engine, described in *Flight* for April 21, 1938, owes its conception to Maurice Gadoux, who was chief engineer of Delaunay-Belleville, and for ten years assistant technical director of the Hispano-Suiza concern.

Six opposed two-cylinder units are grouped around the coaxial propeller shafts in revolver-chamber form, with the cylinders parallel to and equidistant from the shafts. Each separate unit has overhead valves with totally enclosed push-rods and rocker gear. To avoid offsetting the cylinders on the crankshafts one piston of each set of opposed cylinders has a single connecting rod, while the other has two smaller ones placed either side of the former and totaling the same weight as the single one. As shown in Fig. 1, the crankshafts of the six units fall radially around the propeller shafts and each carries a bevel gear engaging, at the front, the bevel gear driving the rear propeller or outer shaft, and at the rear, the bevel gear for the front propeller or inner shaft. Down the center of this inner shaft, passing through both bevel gears and the two propeller hubs, would be placed the shell-gun barrel.

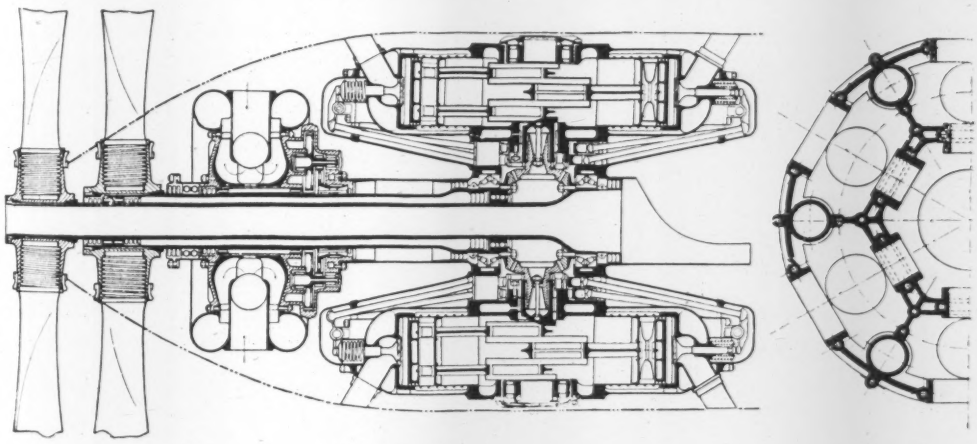


FIG. 1 THE GADOUX 900-HP, 3600 RPM, 12-CYLINDER, SUPERCHARGED ENGINE WITH TANDEM PROPELLERS AND A HOLLOW SHAFT TO BE USED WITH A SHELL-GUN

The bevel gears, besides providing the drive, also take the place of a reduction gear. As the total output of the engine comes, in effect, from six sources and the power from each source is divided between two propellers, the load transmitted by any one gear tooth at any moment cannot be more than one twelfth of the engine's total output. This splitting-up of torque is said to give very smooth performance and it would appear that there is less chance of failure than in the case of, say, a spur-type gear where the whole power is being transmitted at any one moment by a single tooth. The six units of 150 hp each are ethylene-glycol-cooled and each cylinder has a bore and stroke of 6.3 by 4.3 in., a total displacement of 1560 cu in. for the complete engine.

The idea of using concentric or tandem propellers is not new, such propellers were described in this section in the April, 1938, issue of MECHANICAL ENGINEERING. It is claimed that tandem propellers are smaller in diameter without sacrifice of efficiency, torque reaction is automatically canceled by the propellers rotating in opposite directions, and, finally, the air flow from the tandem propellers is undistorted and passes over the airplane fuselage in a smooth stream.

Light for Seeing

AMERICAN STANDARDS ASSOCIATION

SCIENTIFIC research, by ophthalmologists, physicists, physiologists, and others, has added materially in the last few years to our knowledge of the relation between light and seeing. These studies show that not only is light necessary for seeing but that in order to conserve eyesight and to perform the daily visual tasks with accuracy, speed, and comfort, the amount of light should be at least above certain minimums and the lighting of high quality. These developments, together with the accompanying advance in lighting practice and equipment, have made necessary the revision of the "Standards of School Lighting, 1932," by the American Standards Association. In the new edition, entitled, "American Recommended Practice of School Lighting," the primary purpose has been to establish criteria of good illumination for the guidance of architects, engineers, school officials, and others interested in the conservation of children's vision and the efficiency of pupils and teachers. The previous minimum of 8 footcandles is raised to 15, with values of 20 footcandles and more being suggested.

A summary of results of extensive tests, revealing the influence of illumination upon important aspects of visual efficiency and upon even more important effects of seeing, are shown in Fig. 2 which is one of the illustrations in the new code. It is recommended, as a result of these tests, that schoolroom lighting should be prescribed and appraised in terms of quantity and quality. The quantity of light in terms of footcandles or units of illumination may be measured simply and with suitable accuracy by small light meters. Further, children whose eyes, because of defects, are handicapped, should be placed in sight-saving classrooms which have somewhat higher values of illumination than the average rooms.

The quality of the lighting, whether natural or artificial, is

important from both the psychological and the physiological viewpoints. Glare, diffusion, direction, composition, and distribution have significant effects on seeing conditions and should be given due weight. Besides the actual provisions for natural and artificial illumination, special consideration must be given to the physical characteristics of the room and its equipment which affect lighting and seeing. Extreme conditions which should be avoided are direct glare from the source of light and reflected glare from shiny surfaces on walls, ceiling, or work area.

To compensate for inadequate daylight in the inner part of a classroom farthest from the windows, a row of lights operated

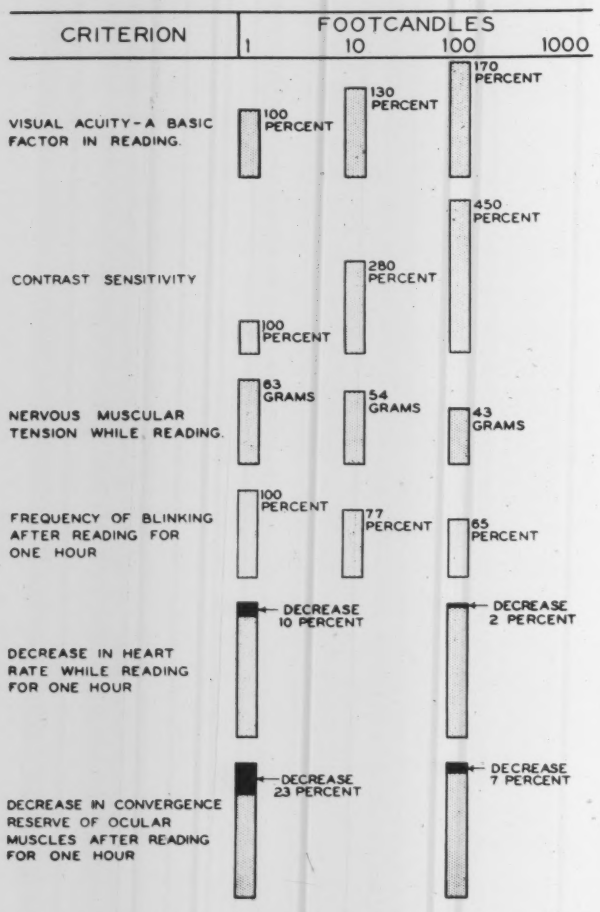


FIG. 2 VARIABLE LIGHT INTENSITIES AND THEIR EFFECT ON THE READER

independently, should be on continuously in this section. The other row of lights may be operated by a photoelectric relay which can be relied upon to follow the changes of daylight and make correction when needed even though the variation is so gradual as to escape attention.

In school shops, industrial types of direct-lighting equipment are suitable. Particular attention should be paid to the location and spacing of these direct-lighting units to minimize shadows and reflected glare. It is desirable to make use of concentrating direct-lighting reflectors or industrial spotlights to add a higher value of illumination at the points of operation of moving machinery to permit accuracy of work and as a safety measure.

A booklet for the use of plant and industrial engineers entitled, "Code of Lighting: Factories, Mills, and Other Workplaces," prepared in 1930 under the rules of procedure of the A.S.A by a committee on which the A.S.M.E. was represented, is now being revised under the sponsorship of the Illuminating Engineering Society.

Future of Higher Education

HARPERS MAGAZINE

NOT LONG ago attention of readers of MECHANICAL ENGINEERING was called to some remarks on education made by the distinguished president of Harvard University, James Bryant Conant. In *Harpers Magazine* for May, Dr. Conant expands these remarks in an article entitled, "The Future of Our Higher Education." Although engineering is not specifically mentioned as are the professions of law and medicine, there will be many who will apply the principles set forth in the article to the training of engineers, and hence the views expressed are important.

Mr. Conant quotes from a "recent history of the American Republic," the following description of two different currents in the democratic reform of education, as follows:

"Jefferson . . . proposed to train an intellectual aristocracy—one selected for 'genius and virtue,' not anyone who had the ambition—to serve the Republic. And he proposed to do this in colleges and universities free from sectarian or political control, in order to give the scholar's mind free play. Jacksonian Democracy, on the contrary, affirmed that all men were born equal, envied intellectual preeminence, and preached the doctrine of equal educational privileges for all."

"To my mind," says Mr. Conant, "Jefferson's proposal—'to cull from every condition of our people the natural aristocracy of talent and virtue'—was so democratic as to be revolutionary." This task of "culling" is the central theme of Mr. Conant's article. "Selection is not a 'weeding out process,'" he explains, "it is one aspect of educational guidance which has as its aim the direction of every youth into a fruitful field of labor. Only a relatively few should proceed through the long and somewhat tedious process of 'book learning' that leads to the professions. The others should receive a training which not only equips them for work in certain vocations but prepares them for life as well-rounded, intelligent, and useful citizens in a democratic society." And right here the remark may be interjected that the vocational and professional character of engineering will be assessed differently by different persons.

In Dr. Conant's opinion there are probably too many rather than too few students attending the universities (not the colleges) of the country, and he questions the desirability of increasing materially the number in our professional schools. He calls attention to the problem of unemployment in the learned professions and suggests that "the country at large would benefit by an elimination of at least a quarter, or perhaps one half, of those now enrolled in advanced university work, and *the substitution of others of more talent in their place.*" Italics have been supplied because Dr. Conant's remarks have been interpreted by some as indicating an undemocratic objective, whereas a careful reading indicates that just the reverse is true. For, he continues, "there is . . . . only one way to provide a university education for the promising youths who are now debarred by economic and geographic factors; by a generous subsidy—by large scholarships, or by providing opportunities for earning a sizable amount of money." How this is carried out at Harvard College by means of "National Scholarships," he briefly describes.

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers in Previous Issues

Grinding of Carbide-Tipped Tools

To the Editor:

Supplementing the paper[1] on the grinding of cemented-carbide tools, which was presented by Mr. Judkins at the Annual Meeting in New York City last December, I would like to contribute a few comments. Cemented-carbide grinding practice, up-to-date, has been adopted from previous experiences with tool and high-speed steels and cast metals, such as Stellite, and is based upon the characteristics of a straight tungsten carbide. With the introduction of tungsten carbide as a cutting material and the development of a silicon carbide wheel that was installed on conventional grinding equipment, the grinding problem was practically solved until the introduction of compositions containing titanium and tantalum to create a characteristic that is favorable for the cutting of steel took place.

Considerable experience in Europe, especially in Germany where these new compositions are already being used extensively, has been accumulated and is at hand. Based on this information, I wish to mention that it is not possible to grind a cemented carbide with a titanium content above 8 per cent or a tantalum content above 12 per cent with the conventional grinding speed of 5000 to 6000 ft by automatic or semiautomatic grinding procedure where the tool is clamped automatically and approaches the wheel, directly or indirectly, through a mechanical device.

The thermal conductivity, which constitutes a vital factor regarding the characteristic of the cemented carbide relative to its handling, is 0.19 [cal/(cm × sec × deg C)] for a straight tungsten carbide, 0.14 for a titanium-tungsten-carbide mixture with 8 per cent of titanium, and 0.09 for a similar mixture with 12 per cent of titanium. Two factors, which are related to each other, are mainly responsible for the destructive action of the wheel on compositions with a low thermal conductivity. These are hardness of the wheel and its speed; however, the latter is the dominating factor.

We have made tests abroad, beginning at 800 fpm, and have found that no particular reason exists for insisting upon a conventional grinding speed of 5000 to 6000 fpm. In fact, it is absolutely necessary to reduce the speed with cemented-carbide compositions of low thermal conductivity to about 2000 fpm, because the action of the wheel creates a certain temperature and amount of heat locally in the top zone of the tip. This heat will not be transferred effectively because of the composition's low thermal conductivity and, at the conventional speed of 5000 to 6000 fpm, is enough to cause destructive local expansion and cracks.

Even if these cracks are not visible, the structure is spoiled, and the tip either will crack later during cutting or regrinding or will flake off continuously. We have also tested grinding at different temperatures of the tool, or submerged in coolant, and with a flexibly applied wheel to control the arbor pressure.

Hand grinding, which is preferable in any case, can be done at the conventional speed because the tool remains in the hand of the operator which has a certain flexibility. If considerable stock is to be removed, the tool should approach the wheel with an oscillating motion to have the smallest possible area of contact.

Machine grinding should only be applied if the form and shape of the tool absolutely require it. Our recommendation is to grind by hand at conventional speeds but to fixture-grind with an open and porous wheel at about 2000 fpm and to dry-grind in any case.

We should like to urge the A.S.M.E. Special Research Committee on Cutting of Metals to institute a research program and investigate the grinding of various cemented-carbide compositions, especially from the viewpoint of grinding speeds, and to inform the trade officially of the necessary facts. Cemented carbides, and especially those with titanium and tantalum contents, are here to stay and will be used more and more. Therefore, this matter is of immediate and great importance.

G. B. Knaepper.[2]

To the Editor:

Although in his estimable paper Mr. Judkins has given us much of worth, he has not touched upon some points and experience has shown that on some points he must be differed with.

Any "lack of confidence" on the part of small-tool men that "good tools tipped with sintered carbide could be made and serviced under practical toolroom conditions" must be laid directly upon the shoulders of the manufacturers of sintered carbides, as their lack of an educational program has caused that "lack of confidence," and to the fact that up to the present the program has been one of sales only, dumping carbides into the laps of prospective customers with no engineering experience or service.

Considerable "scare propaganda" is still attached to the sales effort that is directed toward the introduction of sintered carbides as noted in Mr. Judkin's advocacy of "hydrogen atmosphere" in his brazing furnace. An expensive furnace is not needed to braze carbide-tipped tools, although I would frown on the use of the oxyacetylene torch, except in an emergency. There is no need of using hydrogen. Any cheap furnace using gas from the city mains may be used to braze tips on the shank, provided that a surplus of gas above the quantity actually required for heating purposes, or enough to allow the flame to extend for a distance of from 4 to 6 in. beyond the mouth of the furnace, be admitted to the furnace.

Another of the fallacies promulgated by the sales forces of the makers of sintered carbides and carbide-tipped tools is that a coolant must be applied to the surface being ground. A coolant need not be used on the wheel, either in truing up or when grinding the tip. When wet, wheels cut less freely and tend to heat the tip, glazing it over and causing cracks. Mr. Judkins states that a flood of coolant must be supplied at the surface being ground. Our experience, based

[1] "Grinding of Sintered Carbide-Tipped Tools," by Malcolm F. Judkins, Mechanical Engineering, December, 1937, pp. 897–901.

[2] Chief Engineer, American Cutting Alloys, Inc., Detroit, Mich.

upon actual working conditions as well as information from our associates overseas, where ten times as much sintered carbide is now used as in the United States, is that use of a coolant on tools either when ground or when in use, especially those grades used to cut steel, will cause more destruction of tips than the practice of grinding or using dry. My advice is, always grind dry and do not use water on the wheel when truing it up. However, if the user wants to use a coolant when turning steel, he may do so provided that an extra heavy flow be maintained on the work at all times. Even then, there will be danger of cracked tips.

It must be remembered that sintered carbide is not a true metal, although it has some of the characteristics which are imparted to it by the matrix or binder cobalt and consists of hard particles of a chemical substance, WC-TiC, that are held together by a binder cobalt. It has more of the nature of a ceramic, say the material in an earthenware jug or in a brick. If we throw hot water onto or into a cold jug, or pour cold water into a hot jug, it will invariably crack. It must be remembered that heat alone does not destroy the cutting qualities of sintered carbides, so a heat of approximately 1000 F may be found at times, on the cutting edge of the tip, and also that steel-cutting carbides are not good conductors of heat. Therefore, all of the heat produced in cutting metals is not carried to the shank but lies at the surface of the material. Any heat that is carried away must be diffused by the chip or through the work. If the chip should suddenly break away close to the work, so as to allow coolant to hit the hot tip, a crack will always result. For that reason, we say grind and use dry if possible.

Mr. Judkins, throughout his article, advocates use of a diamond wheel and, in some cases, a diamond lap, but my experience is that neither one is needed. In my own practice of instructing users of sintered-carbide tipped tools, I have abolished the diamond wheel entirely, except where a sharp recess corner is desired. This corner cannot be readily formed with the soft wheels required to grind carbides without an undue loss of wheel surface because of wear. My custom for general tool grinding is to use a medium-hard green silicon carbide wheel of 60 grit for roughing and 120 grit for finishing, and then to use a 220-grit hone to refine and, to a certain degree, present the cutting edge of the tip. The fine particles of hard carbide, hanging loosely in the cobalt binder or matrix at the edge must be removed with the hand hone or they may be forced into the matrix between adjacent grains to form a crack. Again, they may break out in use, taking other grains with them to form a recess that may result in a chip being flaked out of the tip, but to do this lapping nothing is required other than a 220-grit silicon carbide hand hone.

Machine or automatic-machine grinding may be readily done if the user will provide a machine running at a much slower speed than any now in use. I would not recommend a surface speed of over 2000 fpm and 1880 fpm would be sufficient for the best work. At this speed, the feed should not be over 0.00025 in. at any time and, to avoid building up pressure on the tip, generating heat and causing cracks, at least two passes of the wheel over the work should be made before feeding again, and the wheel should be moved over the work rather rapidly. The pressure that can be applied has a limit as well as the speed at which the wheel can be run for good effect. Pressure can be applied or speed increased and the wheel cut-out rapidly or light pressures can be used with slow speeds and the carbide tip cut rapidly. One maker of grinders for carbide-tipped tools states that a speed of less than 2000 fpm is desirable but that it is impossible to get the user to adopt this speed as he has been told for years that high speeds must be used in all grinding practice if the best results are to be had.

It is far easier to instruct the apprentice in the technique of handling carbides than it is to instruct the old "head" who has had years of experience in handling high-speed steel or Stellite tools. The apprentice has everything to learn and nothing to forget, while the old mechanic must forget old practices and learn new ones at the same time.

C. G. WILLIAMS.[3]

TO THE EDITOR:

I must take issue with Mr. Knaepper on several points. First, cemented-carbide grinding practice has not been largely copied from previous experiences with tool steel and cast cutting alloys. These latter materials have never been ground with silicon carbide wheels that were developed especially for sintered carbides. Practices established for carbide grinding involving wheel speeds in the neighborhood of 5000 surface fpm are the result of careful and extended tests made by our company in collaboration with leading grinding-wheel manufacturers. The speeds reported and recommended in my paper were found to correspond to the most efficient cutting action maximum rate of stock removal with minimum wheel wear and no detrimental effects upon the carbide tips. Mr. Knaepper in effect claims that considerable experience in Germany with tantalum and titanium carbides has proved the necessity of low wheel speeds. I do not believe that tantalum carbide has been used in any appreciable quantity in Germany. Most so-called titanium-carbide cutting materials are actually more than 75 per cent tungsten carbide for which no one can deny that high grinding-wheel speeds are necessary. We have no quarrel with low grinding-wheel speeds except that cutting action below 5000 fpm is poor and wheel wear is so rapid that grinding costs mount sharply. We manufacture all types of sintered carbide and, at 5000 fpm we have no trouble in the form of heat checks, cracking, or poor cutting performance. Perhaps the reason for this is because we, unlike Mr. Knaepper and his associates, prefer wet grinding which keeps the tool cool.

Mr. Williams' remarks are rather contradictory. He asserts that lack of confidence of small-tool men that good carbide-tipped tools could be made readily is the fault of suppliers. When we recall the many technical talks and the voluminous literature, both technical and in the form of engineering bulletins and advertising, that suppliers have contributed over the last ten years and the fine work that the grinding-wheel manufacturers have done with their illustrated pamphlets and booklets, it is difficult to place any blame except upon those who have not taken the trouble to become well informed on the subject.

I must answer the accusation that we recommend an expensive brazing furnace. Our furnace is one of the least expensive controlled-atmosphere furnaces on the market, both as to first cost and operation or maintenance. The muffle and heating elements last about 800 hr each and one hydrogen tank will last three days or more. The only trouble with a gas furnace is that to get a neutral or non-cutting atmosphere, let alone a reducing atmosphere such as hydrogen provides, it is necessary to use such an excess of gas that it is almost impossible to get the tool hot enough to melt the copper with the result that brazing is slow. Hydrogen serves several useful purposes. It protects both tip and shank from scaling or oxidation, thus insuring a clean brazed joint; it deoxidizes the copper, improves its strength, and enables it to flow readily with only a few degrees of

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superheat above the melting point.

Regarding Mr. Williams' remarks on the superiority of dry over wet grinding, we can only remark that, based on our extensive experience, it would seem that some, if not most, of the cracking difficulties due to poor heat-transfer characteristics of tantalum and titanium carbides could be avoided if he used some of nature's best coolant, water. Dry grinding must be slow grinding. If Mr. Williams finds that a coolant tends to glaze the grinding wheel and causes it to cut less freely, then he must be using both the wrong wheel and the wrong wheel speed.

Mr. Williams' analogy of sintered carbides to ceramic materials does not fit the known facts concerning these materials. The great majority of hard carbide tools used in this country are composed largely or entirely of tungsten carbide and cobalt. The former is an intermetallic compound having all the properties of a metal and none of a nonmetal. It has high thermal and electrical conductivity, great density, higher compressive strength than any known material (which surely is not a property of bricks or earthenware jugs) high metallic luster, and superlative hardness.

We advocate free use of coolants in both grinding and cutting with tungsten carbide and a grinding crack is unknown in our shop. Mr. Williams fears that the sudden cooling of a hot tip during grinding or cutting may crack the carbide. Effective application of coolant will prevent the tips' getting hot. Dry grinding and dry cutting produce excessive heating and provide no means of cooling.

I do not believe that many tool users will agree that diamond wheels and lapping should be abolished. Many tools, such as piston-grooving, forming, skiving, and broaching tools, reamers, grinder rests, and the like, must be lapped; they always have been and probably always will be. Lapping all tools is beneficial because it minimizes tool-chip friction and prolongs life. We use and recommend diamond wheels because, in many cases, they give much better results than silicon carbide wheels. It is difficult to surface-grind piston-grooving tools or any other precise parts free from taper without diamond wheels. They are necessary to grind accurate angles and radii on form tools. Formed abrasive wheels lose their dressed shape almost immediately. Diamond wheels have less tendency to produce grinding cracks because the difference in hardness between diamond and carbide is enough to permit free stock removal without setting up heavy wheelwork reactions. They are valuable in sharpening fluted and multiple-tipped tools. Abrasive wheels wear so rapidly that every tooth must be indicated. Diamond wheels will circle-grind all the teeth in a cutter to the same diameter.

Finally, I wish to point out that only one grinding-machine manufacturer in this country tried to use a slower wheel speed than 5000 fpm. Excessive wear of even the special wheels made purposely for this machine has, however, forced this manufacturer to adopt that now almost standard wheel speed.

In the oral discussion that followed the presentation of the paper, P. T. Wetter deplored the fact that we have not checked with leading European practice. We did. Dr. Hinnüber, chief engineer of the Krupp works at Essen, visited our plant this year and pronounced our grinding methods virtually the same as theirs.

MALCOLM F. JUDKINS.[4]

[4] Chief Engineer, Firthite Division, Firth-Sterling Steel Company, McKeesport, Pa. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of March 25, 1938, which were subsequently approved by the Council.

CASE NO. 847

(Annulled)

CASE NO. 853

(*Special Ruling*)

Inquiry: In the construction of jacketed low-pressure heating boilers, is it permissible to conceal the water gage glass, particularly where the jacket construction is such that a panel is readily removable for water-level checking?

Reply: It is the opinion of the Committee that all water gage glasses on jacketed heating boilers must be so installed that the entire gage glass can be seen and be accessible at all times. The entire gage glass may be installed inside the jacket provided the jacket is cut away with or without a glass panel in the opening, and such panel is easily removable without tools, and also provided that by the removal of such a panel or panels water gage valves, try cocks, steam gage siphon, and combustion and low-water controls are readily accessible.

CASE NO. 855

(*Special Ruling*)

Inquiry: The end closures of unfired pressure vessels are frequently made so as to be readily removable. A commonly used construction is to make a cast-steel ring with an outer bolting flange and an inner lip to which a dished plate steel head is welded. Will this construction meet the intent of the Unfired Pressure Vessel Code, and if so, what are the limitations?

Reply: It is the opinion of the Committee that the construction described in the inquiry will meet the intent of the code provided:

(1) The dished portion of the head is designed in accordance with the rules for dished heads, allowing for the efficiency of the welded joint.

(2) The length of the "lip" of the steel casting (measured as indicated in Fig. 35) is not less than 3 times the thickness of the steel plate.

(3) The thickness of the cast-steel lip shall be not less than the thickness of the steel plate and shall be approximately the same thickness as the plate at the joint.

(4) If a corner radius is used on the steel casting, it shall be in accordance with the code requirements for a dished

head based on the thickness of the cast-steel lip.

(5) The stresses in the lip of the casting may be calculated as the section of a sphere but shall not exceed the maximum allowable working stresses provided for cast steel, allowing for the efficiency of the welded joint.

(6) If the vessel, of which the head is a part, requires stress relief under the code rules, the joint in the head must also be stress relieved and if the vessel is required to have its joints radiographed, this head joint must also be radiographed.

FIG. 35 COMPOSITE DESIGN OF WELDED HEAD WITH STEEL PLATE CENTER AND OUTER CAST STEEL BOLTING RING

CASE NO. 856

(*In the hands of the Committee*)

CASE NO. 857

(*Interpretation of Pars. P-102j and U-68l*)

Inquiry: Pars. P-102*j* and U-68*l* state that the inspector has the right to call for and witness the making of test plates for qualification tests which shall be not less than the approximate thickness of the plate or parts on which the welding operator is to work. As the same skill is required in producing sound weld metal in plate $1^1/_2$-in.-in thickness as in plate of heavier thickness, it would seem that test specimens within this range of thickness should be acceptable.

Reply: It is the opinion of the Committee that such test specimens need not exceed $1^1/_2$ in. in thickness.

CASE NO. 858

(*Interpretation of Specifications S-18*)

Inquiry: It is noted that there are no provisions in the code for use of tube material equivalent to A.S.T.M. Specifications A 106–36, although the latter are in part equivalent to Specifications S-18. Will it be permissible to utilize tube material meeting the requirements of A.S.T.M. Specifications A 106–36 provided it conforms also to Specifications S-18?

Reply: It is the opinion of the Committee that tube material conforming to A.S.T.M. Specifications A 106–36 is, with the exception of grade C material, acceptable under Specifications S-18. It is pointed out that the latter specification provides for no grade that corresponds to grade C in A.S.T.M. Specifications A 106–36.

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets.

Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

FOREWORD. Replace second sentence by the following:

As the primary object of these rules is safety, the interests of users of boilers and pressure vessels are of paramount importance. The rules have been formulated to afford reasonably certain protection of life and property and to provide a margin for deterioration in service so as to give a reasonably long, safe period of usefulness. The interests of manufacturers have also been recognized by taking into consideration advancements in design and material and the evidence of experience.

PAR. P-9*a*. Revise second sentence to read:

Steel castings for pressure parts shall be made by the electric-furnace, open-hearth, or crucible process.

PAR. P-17. Revise last sentence to read:

The minimum thickness of plates which are to be supported by staying shall be $^5/_{16}$ in.

PARS. P-102*j* AND U-68*l*. Revise second sentence of fourth section to read:

For such qualification tests, the thickness of the test plate shall be approximately the thickness of the plate or parts on which the welding operator is to work except that it need not exceed $1^1/_2$ in.

PAR. P-103*a*. Revise to read:

a The materials used in the fabrication of any fusion-welded drum, shell, or parts covered by this code shall conform to Specifications S-1, S-2, S-4, S-26, S-27, or S-28, grade A, of Section II of the code. Pipe or tubing shall conform to Specifications S-17, S-18, S-32, or S-40. The carbon content in all such material shall not exceed 0.35 per cent.

PARS. P-104*c* AND U-72*d*. Revise to read:

The edges of the plates at the joints shall not have an offset from each other at any point in excess of one quarter of the plate thickness at the joint, with a maximum permissible offset of $^1/_8$ in. for longitudinal joints and $^1/_4$ in. for girth joints.

PARS. P-104*d* AND U-72*e*. Add the following:

In longitudinal shell joints the middle lines of the plate thicknesses shall be in alignment, within the fabricating tolerances specified in (*c*) (*d*) above.

PARS. P-111 AND U-79. Revise to read:

The cylinder or barrel of a drum or shell shall be circular at any section within a limit of 1 per cent of the mean diameter, based on the difference between the maximum and minimum mean diameters at any section, and if necessary to meet this requirement shall be reheated, rerolled, or re-formed. To determine the difference in diameters, measurements may be made on the inside or the outside, and when the cylinder or barrel is made of plates of unequal thicknesses, the measurements shall be corrected for the plate thicknesses as they may apply, to determine the diameters at the middle line of the plate thickness.

PAR. P-112. Revise to read:

P-112 *Welded Connections*. *a* When the welds are not in contact with furnace gases, pipe and tube connections for steam not exceeding 14 in. in inside diameter or for water not exceeding 6-in. pipe size, up to and in-

cluding the valve or valves required by the code, may have fusion-welded circumferential joints.

b When the welds are in contact with furnace gases, boiler, water-wall, economizer, and superheater tubes may have circumferential joints fusion welded provided such connections subject to radiation from the furnace shall not exceed 4 in. in diameter and 1/2 in. in thickness and such connections not subject to radiant heat shall not exceed 5 1/2 in. in diameter and 3/4 in. in thickness. A weld in a portion of a tube that has five or more rows of tubes between it and the furnace will be considered as not subject to radiant heat from the furnace.

c The materials used shall comply with the requirements of Par. P-103. When dissimilar materials are used, it shall be demonstrated that such materials are weldable to each other. No radiographic examination or hammer test of such welds is required.

d All circumferential fusion-welded joints in tubes, welded in accordance with the provisions of this paragraph, shall have single-welded butt joints made the equivalent of a double-welded butt joint (See note in Par. P-101).

The butt weld shall be reinforced at the center of the weld by at least 1/16 in. The strength of the weld shall be sufficient to develop the full strength of the tube. There shall be no valley or groove along the edge or in the center of the weld, and the deposited metal must be fused smoothly and uniformly into the tube surface at the top of the joint. The finish of the welded joint shall be reasonably smooth and free from irregularities, grooves, or depressions. The design of and the method of welding the joint shall be such that there will be no appreciable projection of weld metal past the inside tube surface.

If backing rings are used they shall either be removed after welding or shall be fused integrally with the weld. A backing ring which is to be left in the tube shall be limited in minimum inside diameter to 3/16 in. less than the nominal or maximum permissible inside diameter of the tube, shall be not more than 3/8 in. wide, and shall have a rounded contour on the projection into the tube so that there will be a minimum restriction to flow in the tube, and to permit the use of tube cleaners past the joint. Some acceptable designs of backing rings and joints are shown in Fig. P-5 1/2. These dimensions for backing rings are for tubes up to and including 5 1/2 in. in diameter, and if applicable may be used for larger sizes.

e A sample welded joint shall be made for each 25 or less joints that are welded, of a size selected by the inspector. The sample joints shall meet the test requirements of (*f*).

f (Present Par. P-112*b* in the code.)

PAR. P-180. Change references in first and last sections from "700 F" to "650 F;" Par. U-77, in the example given change "700 F" to "650 F;" Pars. P-195 and U-36, change the reference to "700 F" in the definition of "TS" to "650 F."

PAR. P-186*c*. Add the following:

Any crevices between the mud ring and the sheets of the furnace section of a locomotive-type boiler may be made tight with seal welding when the mud ring is secured by rivets. The abutting ends of mud rings may be welded.

PAR. P-194. Insert the following as (*b*):

b The joints of a dome may be welded and the dome welded to the shell if the welding complies fully with the requirements for welding in Pars. P-101 to P-111, inclusive, and P-268*o*. The opening shall be reinforced in accordance with Par. P-268.

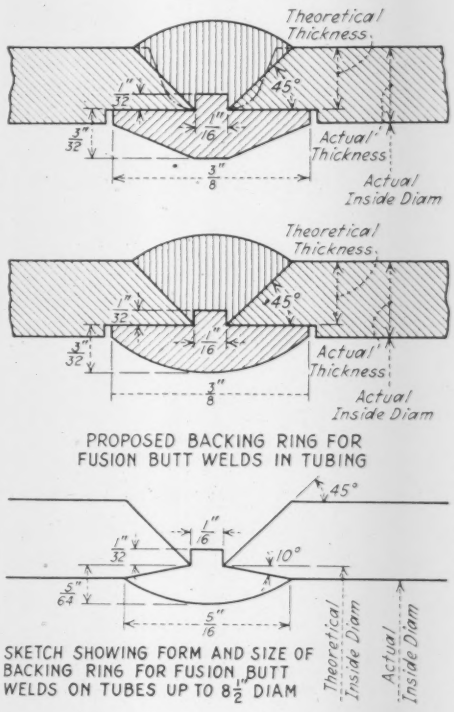


FIG. P-5 1/2 TYPICAL BACKING RING PROPORTIONS FOR USE IN MAKING FUSION BUTTWELDS OF BOILER TUBING

PAR. P-195*f* AND FIRST SENTENCE OF PAR. U-36*f*. Revise to read:

No head, except a full-hemispherical head, shall be of a lesser thickness than that required for a seamless shell of the same diameter.

PARS. P-195*i* AND U-36*i*. To be deleted. PARS. P-195*b* AND U-36*b*. First sentence to be revised to read:

The radius to which a head is dished shall be not greater than the outside diameter of the flanged portion of the head.

PAR. P-195*n* AND PAR. U-36*m*. Add the following:

The thickness of a blank unstayed full-hemispherical head with the pressure on the concave side shall be calculated by the following formula:

$$t = \frac{5 \times P \times L}{2 \times TS \times E}$$

where

t = minimum thickness of head, in.

P = maximum allowable working pressure, lb per sq in.

TS = tensile strength, lb per sq in., originally stamped on the plate or slab used in forming the head. For temperatures over 650 F, 5 times the value given in Table P-9 (Table U-3) shall be used.

L = radius to which the head is formed, measured on the concave side of the head, in.

E = efficiency of weakest joint used in forming the head, including the joint to the shell;

for riveted joints = calculated riveted efficiency.

for fusion-welded joints = efficiency specified in Par. P-102 (Pars. U-68, U-69, and U-70).

for seamless shells with integral heads = 100 per cent.

The above formula shall not be used when the thickness of the head exceeds 20 per cent of the inside radius.

Joints in full-hemispherical heads, including the joint to the shell, shall be governed by and meet all the requirements for longitudinal joints in cylindrical shells, except that in a butt-welded joint attaching a head to a shell the middle lines of the plate thicknesses need not be in alignment.

PAR. P-195*m* (2) AND PAR. U-36*k* (2). Revise to read:

(2) The maximum allowable diameter of any unreinforced opening in a head, except in a full-hemispherical head, shall not exceed that permitted by the rules in Par. P-268*a* (Par. U-59*a*) for a shell of the same diameter, thickness, working pressure, and material, nor shall it exceed 8 in. in any case.

For unreinforced openings in full-hemispherical heads, the same rule shall apply, except that the value of K used in Par. P-268*a* (Par. U-59*a*) and the chart in Fig. P-40 (Fig. U-4) shall be one-half the value given by the formula therein.

PARS. P-195*o* AND U-36*n*. Add the following:

If a flanged-in manhole which meets the code requirements is placed in a full-hemispherical head, the thickness of the head shall be the same as for a head dished to a segment of a sphere (See section *a* above), with a dish radius equal to eight tenths the diameter of the shell and with the added thickness for the manhole as specified in (*c*).

PARS. P-195*p* AND U-36*o*. Add the following:

All other openings which require reinforcement placed in a full-hemispherical head, including all types of manholes except those of the integral flanged-in type, shall be reinforced in accordance with the rules in Par. P-268*g* (Par. U-59*g*), in the application of which the head shall be treated as a shell of the same diameter, thickness, working pressure, and material. When so reinforced, the thickness of such a head may be the same as for a blank full-hemispherical head. In determining the amount of reinforcement required under Par. P-268*g* (Par. U-59*g*), one half the required thickness of a cylindrical shell as specified therein shall be used.

PAR. P-272. Revise second section to read:

Safety valves may be used which give any opening up to the full discharge capacity of the area of the opening of the inlet of the valve (See Par. P-273*c*), provided that no actions or shocks detrimental to the valve or the boiler are produced by the opening or closing of the valve.

PAR. P-322. Revise to read:

P-322. When the gage glasses and gage cocks required by Pars. P-291 and P-294 are not connected substantially directly to the shell or drum of a boiler, a water column shall be used into which the gage glass and gage cocks shall be connected, except as modified by the text preceding Par. P-1.

The steam connections to a water column shall be on a level with or above the upper gage cock and the upper water-glass connection. There shall be no sag or offset in the piping which will permit the accumulation of water. The pipe shall preferably drain toward the water column.

The water connection to the water column and the boiler shall be on a level with or below the lower water-glass connection and the lowest gage cock. No part of this pipe connection shall be above the point of connection at the water column. The pipe shall preferably drain toward the boiler.

An acceptable arrangement is indicated in Fig. P-46$^1/_2$.

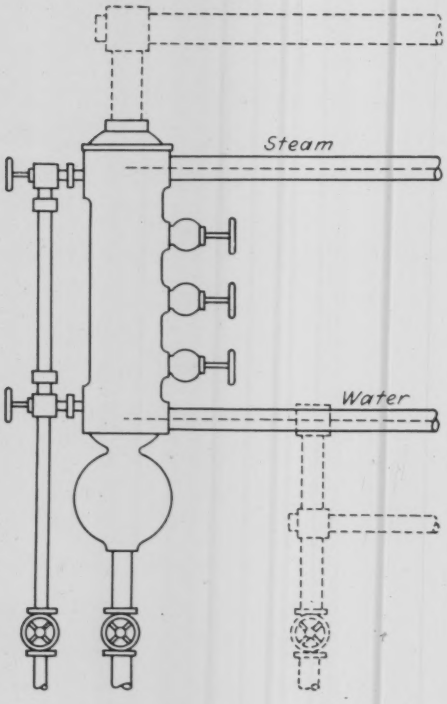


FIG. P-46$^1/_2$ TYPICAL ARRANGEMENT OF STEAM AND WATER CONNECTIONS FOR A WATER COLUMN

PAR. P-329*a*. Add the following to the first sentence:

except that boilers with welded drums or shells shall be tested as required by Par. P-109.

PAR. P-332 (and corresponding requirements in Pars. L-82, H-66, M-20, and U-65). Revise first sentence of (*b*) to read:

b Each boiler, superheater, water-wall, or steel economizer, and parts thereof, constructed to conform with this section of the code, shall be inspected during construction and after completion by a state inspector, a municipal inspector, or an inspector employed regularly by an insurance company. These inspectors shall have been qualified by a written examination under the rules of any state which has adopted this code.

TABLE P-6. Present Table P-6 will be revised in accordance with Table P-8, which appeared in February, 1938, issue of MECHANICAL ENGINEERING, to include stresses for Specifications S-32 and S-40.

TABLE P-7. This table will be replaced by Table P-8 which appeared in the February, 1938, issue of MECHANICAL ENGINEERING.

MANUFACTURERS' DATA REPORTS. A new Manufacturers' Data Report for Water-Tube Boilers has been approved; revisions of the Manufacturers' Partial Data Report have also been approved. Copies of these two forms are available upon application to the Secretary of the Boiler Code Committee.

SPECIFICATION S-1. Add the following footnote:

Steel under this specification may have a copper content not exceeding 0.35 per cent.

SPECIFICATION S-18. Add the following to parenthetical note following title:

Tubes complying with A.S.T.M. Specification A 106–36, welded open-hearth, and seamless steel, grades A and B, will be acceptable as complying with Specification S-18, open-hearth welded, low-carbon, and medium-carbon grades. There is no grade in Specification S-18 which corresponds to grade C of Specification A 106-36.

SPECIFICATION S-42. Reference to this specification will be included in Pars. P-2*a*, P-15, P-103*c*, Tables P-6 and P-7, L-2, L-3, L-5, U-13*a*, U-71, U-120.

SPECIFICATION S-43. Reference to this specification will be included in Par. P-2*a*, crushing strengths in Par. P-16; L-2, L-3, and L-5, crushing strengths in L-12; U-13*a*, U-13*c*, and U-120.

SPECIFICATION S-44. Reference to this specification will be included in Pars. P-2*a*, crushing strengths in P-16, P-103*a*, Tables P-6 and P-7, L-2, L-3, L-5, crushing strengths in L-12, U-13*a*, U-13*c*, U-71, and U-120.

SPECIFICATION S-34 and S-45. Reference to these specifications will be included in Par. P-11, Tables P-6 and P-7, and Specification S-45 in P-3.

SPECIFICATION S-47. This specification will replace reference to S-29, S-30, and S-31 in Table P-8, Par. U-13*f*, and Table U-4.

PARS. H-43 AND H-96. Revise first sentences to read:

Each steam boiler shall be provided with one or more safety valves of the spring pop type, with a lifting device when required by Par. H-49 (H-102), and adjusted and sealed to discharge at a pressure not to exceed 15 lb per sq in.

PARS. H-44 AND H-97. Revise first sentences to read:

At least one water-relief valve, with a lifting devise when required by Par. H-50 (H-103), shall be connected to each hot-water heating or hot-water supply boiler.

PAR. M-16. Revise to read:

M-16. *a* Each miniature boiler shall be equipped with a sealed spring-loaded pop safety valve, not less than $^1/_2$ in. in diameter, connected directly to the boiler. Where there is no extraction of steam (closed system), a fracturing disk safety valve may be used in addition to the spring-loaded pop safety valve.

b Each safety valve shall be plainly marked by the manufacturer in such a way that the markings will not be obliterated in service. The markings may be stamped on the casing, or stamped or cast on a plate or plates securely fastened to the casing, and shall contain the following markings:

(1) The name or identifying mark of the manufacturer.
(2) Manufacturer's design or type number.
(3) Size.....in. Seat diameter....in. (The pipe size of valve inlet.)
(4) Pres.....lb (The steam pressure at which it is to blow.)
(5) B.D.....lb (Blowdown-difference between opening and closing pressure.)
(6) Cap.....lb per hr.
(7) A.S.M.E. symbol as shown in Fig. M-1$^1/_2$ (same as Fig. P-44).

(Insert here the second and third sections of Par. P-273.)

c The minimum relieving capacity of the safety valve shall be determined on the basis of 3 lb per hr per sq ft of boiler heating surface, and shall be sufficient to discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6 per cent above the maximum allowable working pressure.

d If the safety valve capacity cannot be computed, or if it is desirable to prove the computations, it may be checked in any one of the following ways, and if found insufficient, additional capacity shall be provided:

(1) By making an accumulation test, that is, by shutting off all other steam-discharge outlets from the boiler and forcing the fires to a maximum. The safety valve equipment shall be sufficient to prevent the pressure rising more than 6 per cent above the maximum allowable working pressure.

(2) By measuring the maximum amount of fuel that can be burned and computing the corresponding evaporative capacity upon the basis of the heating value of the fuel (See Appendix, Pars. A-12 to A-17).

(3) By determining the maximum evaporative capacity by measuring the feed water. The sum of the safety-valve capacities marked on the valves shall be equal to or greater than the maximum evaporative capacity of the boiler.

e The safety valve or valves shall be connected to the boiler independently of any other steam connection, without any unnecessary intervening pipe or fitting. Such intervening pipe or fitting, if unavoidable, shall not be

longer than the corresponding face-to-face dimension of a tee fitting of the same diameter, and the minimum opening therethrough shall be at least equal to the area of the valve inlet. No valve of any description shall be placed between the safety valve or valves and the boiler, nor on the discharge pipe from the safety valve to the atmosphere.

f To insure the safety valve being free, each valve shall have a substantial lifting device by which the valve disk may be lifted from its seat when there is at least 75 per cent of full working pressure in the boiler. The lifting device shall be such that it cannot lock nor hold the valve disk in lifted position when the exterior force is released. All safety valves shall be mounted with their spindles verticle in an upright position and freely accessible.

PAR. M-18. Revise first sentence to read:

All boilers operated with gas, oil, or mechanical firing shall be provided with an automatic fuel cut-out.

PAR. MA-5. Omit.

PAR. MA-2. Replace by Par. UA-30.

PAR. MA-3. Replace by Par. UA-31.

PAR. MA-4. Replace by Par. UA-32.

PAR. MA-5. Insert new paragraph to be identical with Par. UA-33.

PAR. MA-6. Insert new paragraph to read as follows:

MA-6. *Number, Type, and Size of Test Welds. a Butt Joints in Plate.* For butt joints in plate, two test welds shall be made for each process and position to be used in the construction. One test weld shall be made in the minimum thickness and one in the maximum thickness of the material that will be used in the construction, except that the thickness shall not exceed that permitted by Pars. MA-1 and MA-3.

b Lap Joints in Plate. If lap joints are to be used, two single-welded butt joints shall be made for each process and position to be used in the construction, except in no case may the plate thickness for such test welds exceed $^3/_8$ in.

PAR. MA-7. Insert new paragraph to be identical with Par. UA-35.

PAR. MA-8. Insert new paragraph to read as follows:

MA-8. *Test Specimens. Number, Type, and Preparation.* The required dimensions for the test plates and specimen location shall be as given in Fig. MA-1. From each test weld there shall be taken the following test specimens which shall be prepared for testing as shown in the figures referred to:

For single-welded butt joints in plate: Two reduced-section tensile specimens, Fig. MA-3; two free-bend specimens, Fig. MA-5; two root-break specimens, Fig. MA-6; two side-break specimens, Fig. MA-7; two nick-break specimens, Fig. MA-4.

(The figures mentioned to be revised to conform to latest form of Figs. UA-7 to UA-10.)

PAR. MA-9. Insert new paragraph, to read:

a (to be identical with Par. UA-37*a*).

b For single-welded butt joints the lines scribed on the surface as shown in Fig. MA-5 shall be on the surface opposite the root of the weld. The distance between the scribed lines shall be recorded in 1/100 parts of an inch and this measurement recorded as the initial gage length. Initial bends shall be made as shown by the dotted lines in Fig. MA-5 and in all cases the initial bends shall be in relation to the scribed lines as shown in Fig. MA-5. (Remainder of *b* to be the same as third section of Par. UA-37*b*.)

c (to be identical with Par. UA-37*c*).

d (to be identical with Par. UA-37*d*).

e (to be identical with Par. UA-37*e*).

PAR. MA-10. Insert new paragraph to read:

MA-10 *Qualification Tests of Welding Operators.* The procedure for the qualification of welding operators employed upon miniature boilers shall conform to that set forth in Pars. UA-39 to UA-46, inclusive, of the Unfired Pressure Vessel Code.

PAR. M-4. In (*b*) and (*c*) change reference "Par. MA-4" to "MA-10."

PAR. U-1. Add the following as (*d*):

d A vessel may be designed and constructed by a combination of the types of construction given in the code provided that the rules applying to each type of construction are followed and the vessel is stamped as may be required by the code to indicate the most restrictive construction requirements that have been used in its fabrication.

Such a vessel should be limited to the service permitted by that detail of construction having most restrictive requirements.

PAR. U-3. Revise to read:

U-3 *a* Safety valves shall be of the direct spring-loaded type with a substantial lifting device so that the disk can be lifted from its seat when the pressure of the vessel is 75 per cent of that at which the safety valve is set to blow. Seats or disks of cast iron shall not be used.

b Each safety valve, $^1/_2$ in. in size and larger, shall be plainly marked by the manufacturer in such a way that the marking will not be obliterated in service. The marking may be stamped or cast on the casing, or stamped or cast on a plate or plates securely fastened to the casing, and shall contain the following data:

(1) Name or identifying trademark of the manufacturer
(2) Size.....in. (pipe size of valve inlet)
(3) Pressure.....lb (pressure at which valve is set to blow)
(4) Relieving capacity.....lb per hr for steam, and cubic feet per minute for air (valves for use on air tanks).

NOTE: For other substances than steam or air the relieving capacities need not be stated.

PARS. U-13*c* AND U-71*a*. In Par. U-13*c* insert the words "or Specification S-28, grade A" after the words "Specification S-26" in the fourth line; in Par. U-71*a* add the words "S-28, grade A" to the first sentence.

PAR. U-66. Insert the following after the third sentence:

If the circumferential or longitudinal joint or joints of a vessel are brazed, forge welded, or resistance-welded, the vessel shall be stamped under the code symbol with the letters "BRZ," "FGD," or "RES", as the case may be. Where a vessel is built by combination of types of construction, the stamping on the vessel shall indicate the different classes.

PAR. U-73. Add the following to (*c*):

Welding of Shells to Tube Heads. If 80 per cent of the load is adequately supported by

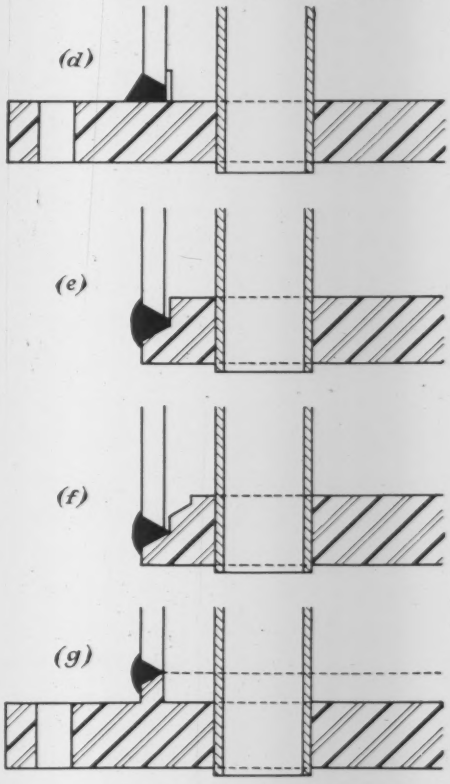


FIG. U-14 WELDED HEAD ATTACHMENTS

steel tubes, stays, or braces, circumferential joints joining shell plates to tube sheets that extend beyond the inside diameter of the shells may be attached by any of the methods shown in Fig. U-14(*d*), (*e*), (*f*), (*g*). Stress relieving is not required unless the vessel itself is required to be stress relieved.

PARS. U-88 AND U-93. Insert the following as new paragraphs:

U-88 (U-93). Openings for pipe connections to vessels having forged (brazed) joints may be made by inserting pipe couplings, not exceeding 3-in. pipe size, or similar devices, in the shell or heads and securing them by fusion welding, without necessitating the application of the paragraph number indicating welded construction as required by Par. U-66. The welding shall be done by operators who are qualified to weld vessels under the provisions of Par. U-69.

PAR. UA-16. Revise to read:

UA-16. *Scope a.* If of steel, bolted flanged connections conforming to the several American standards as given in Tables A-5 and A-6 should be used for connections to external piping and may be used for other flanged connections. Where used for external pipe connections such flanges shall not be used for pressure-temperature ratings exceeding those given in Table A-9.

b Other bolted flanged connections, if of steel, shall be designed in accordance with the rules given in Pars. UA-16 to UA-22, inclusive. These rules are not intended to apply to flanged connections with gaskets extending beyond the bolt circle.

PAR. U-13*g*(6). Add the following:

Bolted flanged connections of cast iron for connection to external piping shall conform where possible to the several American standards for cast-iron flanges as given in Tables A-7 and A-8.

PAR. U-140*b*. Revise to read:

b In addition to complying with test requirements in (*a*), specimens for each impact test shall be cut from one container selected, after heat treatment, from each one hundred containers, or each heat, or each heat-treating batch, whichever is the smaller; and shall

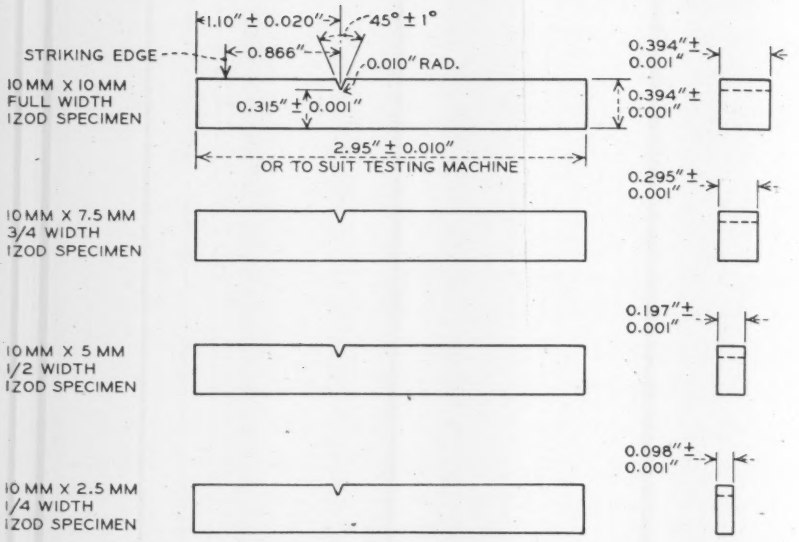

1.10" ± 0.020"
45° ± 1°
STRIKING EDGE
0.866"
0.010" RAD.
0.394" ± 0.001"
10 MM X 10 MM FULL WIDTH IZOD SPECIMEN
0.315" ± 0.001"
0.394" ± 0.001"
2.95" ± 0.010" OR TO SUIT TESTING MACHINE
0.295" ± 0.001"
10 MM X 7.5 MM 3/4 WIDTH IZOD SPECIMEN
0.197" ± 0.001"
10 MM X 5 MM 1/2 WIDTH IZOD SPECIMEN
0.098" ± 0.001"
10 MM X 2.5 MM 1/4 WIDTH IZOD SPECIMEN

FIG. U-27 IZOD IMPACT TEST SPECIMENS

type of machine is not available the Izod test may be substituted. The standard 10 mm × 10 mm specimen shall be used where the thickness is $^{7}/_{16}$ in. or greater, and for thinner material or similar specimen shall be used except that the dimension along the axis of the notch shall be reduced from 10 mm to the largest possible of 7.5 mm, 5 mm, or 2.5 mm.

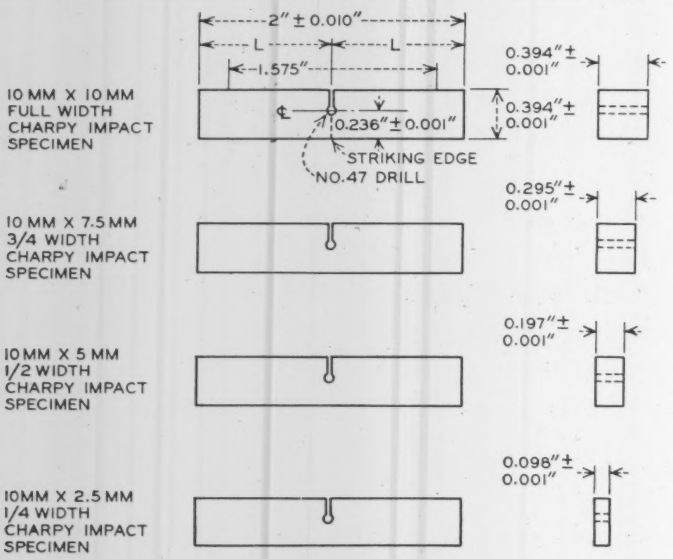

2" ± 0.010"
L
L
1.575"
0.394" ± 0.001"
10 MM X 10 MM FULL WIDTH CHARPY IMPACT SPECIMEN
0.394" ± 0.001"
0.236" ± 0.001"
STRIKING EDGE
NO. 47 DRILL
0.295" ± 0.001"
10 MM X 7.5 MM 3/4 WIDTH CHARPY IMPACT SPECIMEN
0.197" ± 0.001"
10 MM X 5 MM 1/2 WIDTH CHARPY IMPACT SPECIMEN
0.098" ± 0.001"
10MM X 2.5 MM 1/4 WIDTH CHARPY IMPACT SPECIMEN

FIG. U-26 CHARPY IMPACT TEST SPECIMENS (KEYHOLE NOTCH)

meet the impact tests as described in Par. U-142. Each impact test shall be the average from three specimens.

PAR. U-142. Revise to read:

U-142. *Impact Properties and Tests.* (*a*) *Temperature.* Impact tests shall be run at the lowest temperature to which containers may be subjected during the operating cycle. The specimens shall be uniformly cooled by subjecting them to the test temperature for at least 30 minutes and the handling tongs shall be cooled similarly. The tests shall be made within 8 seconds after removal from the cooling medium.

b Tests and Test Specimens. Charpy-type impact tests are preferred; however, where this

c Details of Charpy Test. Charpy tests shall be made on a standard Charpy machine using a keyhole notch specimen as shown in Fig. U-26. The impact properties shall conform to the following:

Charpy impact specimens keyhole notch	Min impact value, ft-lb 0 to —75 F	—76 to —150 F
10 mm × 10 mm	15	10
10 mm × 7.5 mm	12.5	7
10 mm × 5 mm	10	4
10 mm × 2.5 mm	5	2

d Details of Izod Test. Izod tests shall be made on a standard Izod machine using a V-notch specimen as shown in Fig. U-27. The impact properties shall conform to the following:

Izod Impact Specimens V-notch	—Min impact value, ft-lb— 0 to —75 F	—76 to —150 F
10 mm × 10 mm	18	10
10 mm × 7.5 mm	14	7
10 mm × 5 mm	10	3
10 mm × 2.5 mm	4	1

e (Present Par. U-142*c*.)

RECOMMENDED FORM FOR MANUFACTURER'S RECORD OF QUALIFICATION TEST OF WELDING OPERATORS: This form, which appears on page 76 of 1937 Unfired Pressure Vessel Code will be replaced by a Recommended Form for Manufacturer's Record of Qualification of Welding Process, and a Recommended Form for Manufacturer's Record of Qualification of Welding Operators to be consistent with the latest wording of Pars. U-69 and U-70.

TABLE U-4. Substitute the following for the stresses appearing for this material in April, 1938, MECHANICAL ENGINEERING:

		For temperatures not exceeding deg F				
Material	Spec. number	Sub zero	70 to 100	150	250	350
Copper-silicon alloy plates, rods, bars and shapes[5]	S-36 / S-37[1]	10,000	10,000	10,000	8,000	5,000

[5] Not to be used in contact with steam above 212 F.

Reviews of Books

Life Earnings

LIFE EARNINGS IN SELECTED OCCUPATIONS IN THE UNITED STATES. By Harold F. Clark, Harper & Bros., New York, 1937. Cloth, 6 × 9⅛ in., 408 pp. $5.

REVIEWED BY C. J. FREUND[1]

MOST engineers think they are woefully underpaid, and so does everybody else. Journalists envy businessmen their incomes, physicians wish they made as much as lawyers and engineers, and architects and college teachers might be contented if they did as well as bricklayers. Whatever their income, most people apparently wish they earned about a third more, and, in spite of opinions and stories, the average plasterer earns less than the average dentist.

Much additional interesting information may be found in Dr. Harold F. Clark's "Life Earnings" in which he reports the results of his investigation of incomes in the principal professions and in certain other occupations.

Between 1920 and 1936, median annual earnings of engineers were $3700, 25 per cent of engineers earned less than $2550, and 25 per cent earned more than $5620 per year. In the same period, the average engineer earned $4410, while the average physician earned $4850 and the average lawyer $4730. Incomes in all other professions were lower than in engineering.

Average annual earnings in other professions and vocations were as follows:

Architecture	$3820
College teaching	3050
Social work	1650
Journalism	2120
Ministry	1980
Library work	2020
Public school teaching	1350
Skilled trades	1430
Nursing	1310
Unskilled labor	795
Farming	580
Farm labor	485

The familiar typical American, who is successful in his undertakings, joins clubs, drives an expensive car, buys jewelry for his wife, and frequents resorts, belongs to an utterly negligible minority. The vast majority of people do not earn money enough to maintain what is proudly called the American standard of living.

And professional people may expect their income to grow with their experience, but in farming, and in unskilled and semiskilled labor there appears to be no such relation, after the first month or two.

Dr. Clark has assembled a wealth of data and his thoroughness inspires confidence; he has uncovered such remote sources of information that one is forced to conclude that he has omitted nothing of consequence.

At the same time, the reader becomes skeptical about even the most reliable income statistics. Dr. Clark warns that they can be little better than shrewd estimates at best. The more complete the research, the greater the number of complications which make the results doubtful. For instance, what items are properly included in a physician's expense and, accordingly, what is his net income? Do physicians agree on these items? What is the average age and hence, experience, in a given profession, and is it increasing or decreasing? Do reported earnings of individuals include periods of unemployment, and do the reported earnings of groups include the unemployed? Is the turnover in a profession high or low? Do the highly successful or the failures disregard questionnaires, or do they both disregard them?

The book will be valuable primarily for reference purposes, but anybody who has any interest in the question of earnings will enjoy and profit by the first 140 pages, preceding the appendix. Minor inaccuracies in text and arrangement here and there suggest the thought that the author and his associates may have become interested in a later study while preparing this report for publication.

People have to live all year, and make expenditures all year, and for this reason hourly and even weekly income rates are not significant, particularly under modern conditions involving interruptions in employment. For the same reason, Dr. Clark maintains that annual incomes do not fully represent conditions in an occupation. In one line of work, the period of useful activity may be shorter or longer by many years than in another. Accordingly, he has calculated not only life-earning averages for the various professions and occupations but has even determined the present value of those life earnings. These calculations of life incomes and their present value are unique features of the book.

Some of Dr. Clark's ideas will shock most professional people. For instance, he contends that the incomes in all professions are much too high in proportion to other vocations, and he advocates a great increase in the number of engineers, physicians, and lawyers to destroy the financial advantage that they enjoy because their services are relatively scarce. In his opinion, all these professional men should have to compete aggressively among themselves for what work there may be and thus force down the cost of their services. He maintains that this would be advantageous to the community, although he realizes that the professions will probably oppose the plan. In the meantime, he hopes for an increase in the national income, so that earnings will be higher in all vocations, while the wide differences disappear. He takes for granted the desirability of national economic planning.

Dr. Clark is professor of educational economics at Columbia University. His teaching and research have been in the economics and finance of education, and his experience has been principally academic.

[1] Dean, College of Engineering, University of Detroit, Detroit, Mich. Mem. A.S.M.E.

Received in Library

AERO-ENGINES, DESIGN AND PRACTICE (HANDBOOK OF AERONAUTICS). By A. Swan. Sir Isaac Pitman & Sons, London; Pitman Publishing Corp., New York, 1938. Cloth, 6 × 9 in., 483 pp., illus., diagrams, charts, tables, $7.50. This book, which is published with the approval of the Council of The Royal Aeronautical Society, is intended to be an accurate and authoritative collection of information on airplane engines which will be of everyday use to designers and constructors of aircraft. Information upon design and performance data, design and stress calculations, supercharging, carbureting and intake systems, cooling, ignition, fuels and fuel systems, lubricating oils and oil systems, exhaust systems and silencing, engine starters and heaters, compression-ignition engines, and engine testing is provided. The book brings together a vast quantity of scattered information of great value, systematically arranged and thoroughly up-to-date. It can be warmly recommended.

DAVISON'S RAYON AND SILK TRADES. Davison Publishing Co., Ridgewood, N. J., 43rd edition, 1938. Leather, 5 × 8 in., 488 pp., illus. Thin paper pocket edition, $5.50; de luxe office edition, $7.50. A directory of mills, dyers, and finishers in the rayon and silk trades, containing both geographical and classified lists, as well as an alphabetical index. A buyers' guide indicates sources of equipment, and the railroads serving the various plants are indicated by numbers corresponding to a list at the back of the book.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

"Spirit of St. Louis Medal" to Be Presented to J. H. Doolittle at A.S.M.E. Semi-Annual Meeting

British Metallurgist Designated Rice Lecturer

ONE OF the most interesting events of the A.S.M.E. Semi-Annual Meeting in St. Louis, Mo., June 20–23, will be the presentation at the banquet of the Spirit of St. Louis Medal for 1938 to Major James H. Doolittle, internationally known in aeronautical circles and director of aviation for the Shell Petroleum Company in the United States.

Endowed by members of the A.S.M.E. and citizens residing in St. Louis, Mo., to be bestowed for meritorious service in the field of aeronautical engineering, the Spirit of St. Louis Medal is awarded at the discretion of the Council of the Society at approximately three-year periods upon the recommendation of the Board of Honors and Awards of the A.S.M.E.

The citation for the 1938 award reads:

"The Spirit of St. Louis Medal is bestowed upon Major James H. Doolittle for his contributions to the science of aviation and for his achievements in flying, which have aided and extended his scientific accomplishments. Outstanding among the latter are: The first one-stop flight across the American continent in 1922; the world's high-speed record for seaplanes in 1925; the transcontinental record flight from Los Angeles to New York in 1931; and the world's speed record for land planes in 1932.

In addition to these records Major Doolittle contributed largely to the development of aviation in the countries of South America through visits to these republics in 1926 and 1928.

For these reasons the Spirit of St. Louis Medal is bestowed in recognition of 'distinguished achievement in aviation.' "

Advances in metallurgy and engineering during the present century will be reviewed by William Robb Barclay, consulting metallurgist, the Mond Nickel Company, Ltd., of London, England, in the Calvin W. Rice Lecture.

The Rice lecture, which will be delivered at 4 p.m., Tuesday, June 21, will include a review of the evolution of modern alloy steels including high-speed, corrosion, and heat-resisting steels. Dr. Barclay who is the 1931 Thomas Turner Gold Medalist of the University of Birmingham, is a metallurgist of international reputation.

Technical sessions, of which there will be 15 with 34 papers, will commence on Monday evening. Motion study and wage incentives will be discussed at one of the two opening sessions on that evening and conversion burners for domestic furnaces, coal carbonization, and smoke-density measurement are the subjects of three papers at the other.

Society Affairs

Society affairs will be considered at meetings of the Executive Committee and the Council on Sunday afternoon before the meeting opens officially, and Monday morning. On Monday afternoon at 4:30 p.m. a business meeting of the Society is scheduled.

A luncheon meeting on Tuesday noon provides an opportunity to hear Raymond B. Tucker, Commissioner of Smoke Regulation, of St. Louis, speak on smoke abatement. Mr. Tucker's address appeared in the May issue of MECHANICAL ENGINEERING.

Social events are scheduled for Tuesday and Wednesday evenings. At the National Defense Meeting, to be held jointly with the Army Ordnance Association on Tuesday evening, Major John K. Christmas will talk on the manufacture of high-speed tanks. Harvey N. Davis, president A.S.M.E., will be the principal speaker at the banquet on Wednesday evening.

Technical sessions have been arranged for Tuesday, Wednesday, and Thursday mornings, and for Tuesday afternoon, as announced in the program that follows. Wednesday and Thursday afternoons have been set aside for plant visits in St. Louis and vicinity.

The Women's Program

An interesting program has been planned for the women in attendance at the meeting. On Monday evening June 20 they will attend the Municipal opera. On Tuesday morning a visit to the St. Louis dairy is planned where luncheon will be served while in the afternoon the famous Missouri Botanical Gardens will be enjoyed; Tuesday evening's plans call for a boat trip. On Wednesday no one will want to miss seeing the Forest Park Jefferson Memorial where the famous Lindbergh collection of trophies is on view; in the evening, of course, the women will attend the banquet at the headquarters of the meeting, the Hotel Statler. On Thursday the many historical spots of St. Louis and the shopping center are on the program with the opera again in the evening.

With a program like that arranged for them St. Louis is setting a precedent that will be hard for any other section to equal.

WATER TOWER IN RESERVOIR PARK AT COMPTON HILL, ST. LOUIS

To Engineering Educators

Who Plan to Attend Both A.S.M.E. Semi-Annual and S.P.E.E. Meetings

IN CONNECTION with the meeting of the Society for the Promotion of Engineering Education to be held in College Station, Texas, June 27–30, the "Katy Lines" are anxious to be of service in arranging transportation for those attending the A.S.M.E. Semi-Annual Meeting in St. Louis, June 20–24, and who will travel via St. Louis or Kansas City.

Two fast trains from St. Louis to Dallas offer convenient service. The round-trip, 30-day-limit ticket from St. Louis to College Station and return is $37.70. The cost of a lower to Dallas is $5.50; of a chair, $0.75.

W. E. BRYAN

C. J. COLLEY

E. H. SAGER

IN CHARGE OF THE ST. LOUIS A.S.M.E. SEMI-ANNUAL MEETING

(Mr. Colley is Chairman of the St. Louis Section and of the General Committee for the Meeting, Mr. Bryan, is Vice-Chairman, and Mr. Sager, Secretary of the Committee.)

Program of A.S.M.E. Semi-Annual Meeting

St. Louis, Mo., June 20–23, 1938

SUNDAY, JUNE 19

10:00 a.m.

Meeting, Committee on Local Sections

2:00 p.m.

Meeting, Executive Committee of Council

4:00 p.m.

Informal Conference of Council

MONDAY, JUNE 20

9:30 a.m.

Council Meeting

4:30 p.m.

Business Meeting

6:00 p.m.

Dinner, Senior Councilors and Committee on Local Sections

8:00 p.m.

Time Study

Practical Applications of Motion-Study Research, by Ralph M. Barnes

Wage Incentives, by A. B. Segur

Fuels—I

A Down-Draft Conversion Burner for Domestic Furnaces, by J. R. Fellows

Coal Carbonization and Its Relation to the Smoke Problem, by M. D. Curran

Smoke-Density Measurements, by H. E. Bumgardner

TUESDAY, JUNE 21

9:30 a.m.

Boiler Feedwater

Carbonaceous Zeolites—An Advance in Boiler-Feedwater Conditioning, by Howard L. Tiger

New Methods of Boiler-Water Treatment for Prevention of Embrittlement, by F. G. Straub and T. A. Bradbury

Boiler Operation as It Affects Prime Movers, by S. E. Tray

The Behavior of Sodium Sulphite in High-Pressure Steam Boilers, by R. M. Hitchens and J. W. Purssell

Railroad

Locomotive Axle Testing, by T. V. Buckwalter, O. J. Horger, and W. C. Sanders

The Drafting of Steam Locomotives, by J. R. Jackson

Process

Quantitative Analysis of Process Lags, by C. E. Mason

Comparative Analysis of Automatic-Control Theories, by A. F. Spitzglass

12:30 p.m.

Smoke-Abatement Luncheon

Smoke Abatement, Its Past, Present, and Future in St. Louis, by Raymond R. Tucker, Commissioner, Smoke Regulation, City of St. Louis

Discussion by Osborn Monnett

2:00 p.m.

Hydraulic-Power

Operating Problems on Combined Hydro- and Steam-Generating System, by Howard Harrington

Trends in Design of Large High-Pressure Boiler Units, by John Van Brunt

Railroad

An Oil-Bath Lubricated Railway Bearing, by Albert Vigne and I. Eugene Cox

Influence of Pressure on Film Viscosity in Heavily Loaded Bearings, by S. J. Needs

Process

Engineering Phases of Thermoplastics, by J. M. DeBell

The Proportioning of Materials in Process Engineering, by J. C. Witt

4:00 p.m.

Calvin W. Rice Lecture

Some Metallurgical Contributions to Engineering Progress, by William Robb Barclay

Evening

National Defense

The Manufacture of High-Speed Tanks, by Major John K. Christmas

(Address will be followed by Smoker)

WEDNESDAY, June 22

9:30 a.m.

Fuels—II

Fuels for Industrial Heating Furnaces, by Matthew H. Mawhinney

Power Plant Requirements of a Distillery, by H. L. Walton

Experiences and Difficulties in Processing Coal, by L. C. McCabe

Apprenticeship

An Apprenticeship Training Program, by H. L. Humke

Welding and Flame-Cutting Session

Oxy-Acetylene Surface Hardening, by A. K. Seemann

Welding Applied to Plant Maintenance and Repairs, by H. R. Wass

Arc-Welding Costs, by E. W. P. Smith

Afternoon

Plant trips

Evening

Banquet

Dr. Harvey N. Davis, President, A.S.M.E., to speak on "Engineering and Health"

Dean A. S. Langsdorf of Washington University, Toastmaster

THURSDAY, JUNE 23

9:30 a.m.

Flanges

Tests of Heat-Exchanger Flanges, by D. B. Rossheim, E. H. Gebhardt, and H. G. Oliver

Design of Flanged Joints for Valve Bonnets, by J. D. Mattimore, N. O. Smith-Petersen, and H. C. Bell

Surface Finishing

Report on Standardization Roughness Measurements, by J. R. Weaver

Optical Projection, Possibilities and Limitations in Industry, by Henry F. Kurtz

Surface-Finish Measurements, by E. J. Abbott

Iron and Steel

Foundry Maintenance, by Wm. Carter Bliss

Some Engineering Aspects of Cast Irons, by Carl Morken

The Use of Plastic Bronze in Modern Bearing Practice, by C. C. Morgan

Afternoon

Plant trips

Actions of A.S.M.E. Executive Committee

Frederick Lask's Staff Service of 25 Years Recognized

THE April meeting of the Executive Committee of Council of The American Society of Mechanical Engineers was held at the Society headquarters in New York, April 20, 1938. Vice-Chairman James M. Todd presided in the absence of the president. Present at the meeting were Kenneth H. Condit, Harte Cooke, and James W. Parker, of the committee; K. M. Irwin (Finance) and J. N. Landis (Local Sections), advisory members; and C. E. Davies, secretary.

The following actions, of general interest, were taken.

American Engineering Council

W. L. Batt and Harold V. Coes were appointed as a special committee to serve jointly with similar committees of the American Society of Civil Engineers and the American Institute of Electrical Engineers to study recommendations in respect to the American Engineering Council. Attention was directed to the A.E.C. forum, Philadelphia, May 13, on the subject, "Employment and the Engineer's Relation to It."

Franklin Institute Vermilye Medal

An invitation for the Franklin Institute, Philadelphia, Pa., to appoint a representative on an advisory committee to aid in selecting the recipient of the newly instituted Vermilye Medal "in recognition of outstanding contribution within the field of industrial management," was referred to the Board of Honors and Awards.

Twenty-Five-Year Staff Service Recognized

In recognition of 25 years of service on the staff of the Society, a tribute to Frederick Lask, advertising manager, was incorporated in the minutes. [Mr. Lask was also honored by a few of his colleagues at a luncheon on Monday, May 2.]

FREDERICK LASK

The Executive Committee's tribute to Mr. Lask reads as follows:

On May 1, 1938, Frederick Lask completes 25 years of service for the Society. Following his graduation from Cornell University, seven years of general engineering experience, and two years in educational publishing, Mr. Lask came to the advertising department of the Society.

His first responsibility was the organization of the catalog department of the *Journal* which later was expanded to the "Condensed Catalogues of Mechanical Equipment," now designated as the "Mechanical Catalog." His responsibilities were gradually broadened until in 1917 he was appointed advertising manager, in charge of the advertising in MECHANICAL ENGINEERING and "Mechanical Catalog." In 1923 he was given general responsibility for publication sales.

Mr. Lask's service has been characterized by thorough understanding of the aims and purposes of the Society and the ability to carry on the income-producing activities of the Society in accord with them. He has rendered faithful, loyal service with resultant great contribution to Society income and consequent increased usefulness of the Society in carrying out its purposes.

Woman's Auxiliary

Formation of a local section in Cleveland, Ohio, of the Woman's Auxiliary of the Society, was reported in a communication from Mrs. George W. Farny, president of that body.

Tribute to R. J. Durley

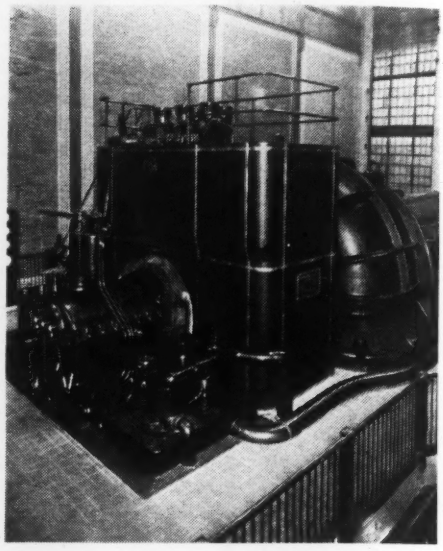
The Secretary was requested to transmit a letter to Richard J. Durley, upon his retirement as secretary of the Engineering Institute of Canada. Capt. Durley's retirement was noted in this section last month.

Senior Councilors

The appointments were reported of R. J. S. Pigott, as senior councilor of Group V, to fill the vacancy caused by the death of B. M. Brigman, and of L. W. Wallace, to serve as alternate for W. C. Lindemann of Group VI.

Appointments

Appointments reported for record were as follows: Delegates to the International Engineering Congress, Glasgow, Scotland, June 21 to 24, 1938, Geo. A. Orrok and George A. Stetson. Special Committee on Registration, V. M. Palmer, chairman (J. Rowland Brown, resigned). Special Research Committee on Condenser Tubes, D. C. Weeks and O. Z. Klopsch. Boiler Code Subcommittee on Care of Power Boilers in Service, Frank Henry and D. C. Carmichael. Representatives at student-branch conferences: Durham, N. H., Harvey N. Davis; Philadelphia, Pa., Harte Cooke; Toronto, Ont., Canada, Harvey N. Davis; Atlanta, Ga., J. M. Todd; Milwaukee, Wis., Harvey N. Davis; Omaha, Neb., Harvey N. Davis; College Station, Tex., E. W. Burbank; Seattle, Wash., Harvey N. Davis; Fort Collins, Colo., Harvey N. Davis; and Los Angeles, Calif., Warren H. McBryde. University of Arizona, Inauguration of President, April 12, M. L. Thornburg. International Congress on Technical Education, Berlin, Germany, July 25 to 29, 1938, Conrad Matschoss.



75,000-KW TURBINE AT CAHOKIA POWER PLANT, IN ST. LOUIS

(A trip to this plant is being arranged during the A.S.M.E. Semi-Annual Meeting in June.)

Mechanical Catalog Expansion Approved by Council to Benefit Members

EXECUTIVE COMMITTEE of the Council of the A.S.M.E. at its meeting of April 20 authorized the reestablishment of the complete directory of mechanical products and engineering materials in the 1938–1939 MECHANICAL CATALOG, which was included prior to 1932. This means that the Catalog will include not only product descriptions but also a complete listing of manufacturers and a classified index of the various equipment manufactured by them. The Council feels that this expansion of the publication will make it more useful to the thousands of A.S.M.E. members who use the book in their daily work.

Approximately 1400 replies were received to the recent questionnaire sent out to all A.S.M.E. members regarding their use and comments on the Catalog. An analysis of the returns indicates that 92 per cent of those answering feel that the Catalog renders a useful service. Many of the constructive thoughts expressed are proving very helpful in the preparation of the forthcoming edition.

G. B. Karelitz to Address Mathematics Convention

PROF. G. B. Karelitz, a member of the A.S.M.E. Standing Committee on Professional Divisions, and on the faculty of Columbia University, has been invited to address The National Council of Teachers of Mathematics during its convention in New York City, June 27–29, 1938, jointly with the National Education Association. His lecture on June 29, will deal with "Mathematics as It Functions in Industries and Business."

Program for National A.S.M.E. Oil and Gas Power Meeting at Dallas, Tex., June 6–9

Well-Balanced Schedule of Technical Papers and Inspection Trips; Special Diesel-Engine Exhibit of Parts and Accesories

DALLAS, "A Friendly City in a Friendly State," will be the host for the first time at the annual national meeting of the Oil and Gas Power Division of the A.S.M.E., June 6 to 9. The North Texas Section of the A.S.M.E. is cooperating with the Oil and Gas Power Division Committee to assure a successful meeting.

Located in the heart of the world's largest petroleum-producing area, Dallas not only offers the necessary environment for a meeting of this kind, but gives assurance that at this time of year Texas temperatures are not high and humidities are low. In any case comfortable conditions are assured because of the availability of air-condition facilities at the Baker Hotel, headquarters for all sessions.

The time of year and the place should make this an ideal occasion for the ladies to accompany their husbands to the meeting. A special committee is making plans for their entertainment with teas, bridge parties, trips, and, of course, the banquet which will be followed by dancing.

Exhibits

Exhibits of Diesel-engine parts and accessories will be held in the convention room, foyer, and the mezzanine lounge of the Baker Hotel. Among the exhibitors will be the Aluminum Company of America, American Air Filter Company, Diesel Equipment Corporation, Double Seal Ring Company, Hercules Motors Corporation, Illinois Testing Laboratories, Koppers Company Piston Ring Division, Motor Improvements, Inc., Scintilla Magneto Company, United American Bosch Corporation, and the Zenith Carburetor Company.

The Program

The following tentative program of technical sessions and other events of the Dallas Meeting is as complete as is possible to include in this issue:

MONDAY, JUNE 6

10 a.m.

Registration opens, Mezzanine Lounge, Baker Hotel

1:30 p.m.

General Session

Welcome by Harry R. Pearson, Chairman, North Texas Section, A.S.M.E.

Progress Reports by Manufacturers of Diesel Engines

Recent Developments, Applications, and Trends of High-Speed Diesel Engines, by C. L. Cummins

Lightweight Materials for Internal-Combustion Engines, by P. B. Jackson

TUESDAY, JUNE 7

9:30 a.m.

Operating Session

Essential Factors Contributing to the Success of a Maintenance Program for Internal-Combustion Engines, by E. R. Spencer

Trends and Load Characteristics of Power Application for Pumping Oil Wells, by W. H. Stueve

Operating Experiences of a Two-Cycle Diesel Engine Using Gas Fuel on Diesel Cycle, by J. J. Graham

2:00 p.m.

Operating Session

Municipal Lighting and Power Systems Using Diesel Prime Movers, by T. B. Connor

Recent Developments of Cooling Towers and Their Application to Gas and Diesel Engines, by G. J. Bischof

Theory, Application, and Benefits of Engine Vibration Isolation, by S. Rosenzweig

4:30 p.m.

Inspection trip to engine room, Lone Star Gas Building

WEDNESDAY, JUNE 8

9:00 a.m.

Transportation and Governing Session

Modern Governing Equipment for Internal-Combustion Engines, by W. J. Whitehead

Sound Films and paper on "The Diesel Engine in High-Speed Railroad Service," by E. F. Weber

1:30 p.m.

Inspection trip to Guiberson Diesel (Aircraft) Engine Company

2:00 p.m.

Committee meetings and Golf Tournament

7:00 p.m.

Banquet (informal) and entertainment, Baker Hotel, Convention Room

10:00 p.m.

Dance (informal), Baker Hotel, Mural Room

THURSDAY, JUNE 9

9:00 a.m.

Design, Fuels, Research Session

Wear of Piston Rings and Cylinder Liners, by Harte Cooke

Latest Developments in Diesel-Fuel Testing, by T. B. Rendel and G. L. Stetson

A New Pressure Indicator for Diesel Engines, by K. J. DeJuhasz

A.S.M.E. Machine Shop Meeting Excells in Good Papers and Lively Discussion

Two-Day Meeting in Rochester, N. Y., Has Over 200 in Attendance at Sessions and Trips

WITH a program of five technical sessions, one of which was in connection with a banquet, the A.S.M.E. Machine Shop Practice Division conducted a national meeting at Rochester, N. Y., May 10 to 12, sponsored by the Rochester Section of the Society. Cooperating with the division in one of the technical sessions was the American Foundrymen's Association. The afternoons of the three days devoted to the meeting provided opportunities for the inspection of six local plants. Headquarters were at the Sagamore Hotel. Upward of 200 engineers were in attendance, nearly half of whom were present at the banquet.

T. F. Hooker Welcomes Those in Attendance

At the opening session T. F. Hooker, chairman of the Rochester Section, welcomed the first hundred arrivals and introduced G. F. Nordenholt, chairman of the Machine Shop Practice Division, who presided. The meeting got off to a good start with a paper by E. W. Brinkman, of the Davenport Machine Tool Company, who described how five-spindle automatics had been equipped with special features by means of which secondary operations formerly performed after cut-off could be completed in the original machine. W. T. Forde, of the International Business Machine Corporation, expanded the subject by an explanation of the economics of the elimination of the secondary operation. Allan H. Candee, of the Gleason Works, presented an excellently organized and fully illustrated exposition of industrial applications of spiral bevel and hypoid gears.

At Tuesday evening's session, Carl L. Bausch, of the Bausch and Lomb Optical Company, spoke on inspection procedure as carried out by that company and as it related specifically to eye-glass lenses. Mr. Bausch is a manager of the Society. T. F. Hooker presided.

Wednesday morning's session was devoted to a discussion of three types of ferrous foundry metals and was held under the joint sponsorship of the American Foundrymen's Association, with Dan M. Avey, secretary-treasurer of the Association presiding. Owing to the critical illness of F. A. Lorenz, Jr., of American Steel Foundries, the paper he had prepared on

steel castings was presented by R. L. Collier, Steel Founders Society of America, and H. J. Schiffli, of American Steel Foundries. Mr. Lorenz is the recipient for 1938 of the Joseph F. Seaman Gold Medal of the American Foundrymen's Association. The subject of gray-iron castings, particularly of the high-strength variety, was discussed by A. C. Denison, president, Fulton Foundry and Machine Company, while the case for malleable castings was presented by Enrique Touceda and J. H. Lansing, of the Malleable Founders' Society.

Fine Discussion on Apprentice Training

With Kenneth H. Condit, vice-president, A.S.M.E., as toastmaster, the banquet on Wednesday evening developed into one of the best discussions on apprentice training ever sponsored by the Society. The speaker, George B. Heddendorf, education department, International Business Machines Corporation, defined apprentice training in its broader aspect of industrial education, and discussed five cardinal policies underlying any such effort in general and the work carried on at I.B.M. in particular. An able speaker, Mr. Heddendorf proved himself to be of the type of teacher he considered ideal for an apprentice training program, and stimulated discussion that kept the audience alert and interested.

The trend in shop practice and drafting was the general subject of the closing session on Wednesday morning. J. R. Weaver, of the Westinghouse Electric and Manufacturing Company, and secretary of the Machine Shop Practice Division, presided, and the speakers were William L. Bond, of the General Electric Company, and W. D. Turnbull, of Westinghouse.

Plant Visits

Plants visited on the three afternoons during the meeting were the camera works of the Eastman Kodak Company, the Gleason Works, Bausch and Lomb Optical Company, Taylor Instrument Companies, American Laundry Machinery Company, and The Consolidated Machine Tool Corporation of Rochester.

Those Responsible

The local committee of the Rochester Section which acted as hosts consisted of T. F. Hooker, chairman, Irvin G. McChesney, secretary-treasurer, M. D. Lee, vice-chairman, and Howard Harding, K. B. Castle, W. T. Cowell, and R. H. Bushley. The arrangements committee included O. L. Angevine and E. J. McGuire, publicity; E. H. Lang, transportation; P. B. Wesson, banquet; I. G. McChesney, program and papers; M. D. Lee and O. L. Angevine, registration and hotel accommodations; K. B. Castle, social events; and R. H. Bushley, inspection trips.

A.S.M.E. Calendar

of Coming Meetings

June 6–9, 1938
Oil and Gas Power Division Meeting
Dallas, Texas

June 20–23, 1938
Semi-Annual Meeting
St. Louis, Mo.

September 12–16, 1938
Applied Mechanics and Hydraulic Divisions Cooperating in International Congress of Applied Mechanics
Cambridge, Mass.

September 22–23, 1938
Wood Industries Division Meeting
High Point, N. C.

October 5–7, 1938
Fall Meeting
Providence, R. I.

October 13–15, 1938
Fuels Division Meeting (jointly with A.I.M.E. Coal Division)
Chicago, Ill.

December 5–9, 1938
Annual Meeting
New York, N. Y.

Washington Section Hears Albert Ramond Defend Bedaux System and Its Application

Claims That System Provides Management With Facts Which Prevent Labor Difficulties

MEETING at the Potomac Electric Power Company Auditorium in Washington, D. C., April 14, members of the Washington Section, A.S.M.E., heard Albert Ramond, president of the International Bedaux Company, Inc., describe the history, various applications, and its relation to labor of the Bedaux system. Due to the general interest in this subject, an abstract of the paper is hereby presented.

According to Mr. Ramond, management strives for low cost, labor strives for high wages, and the two are compatible only where a reasonable labor effort results in productive goods or services with a minimum of waste. Every dollar lost or wasted increases costs or reduces wages, or both. It was with this in mind that the Bedaux method was conceived and developed during the years 1916–1918. The idea was to provide a practical measure of human productivity, a measure not affected by changing conditions and applicable to any form of human labor as long as there existed a relationship between output and physical energy. This gave the desired knowledge of facts and possibilities, facilitating the task of management, and protecting the worker.

The Bedaux Idea

In order to realize this idea, a common denominator of constant value is applied in the Bedaux plan to all human operations, regardless of industry, type, location, etc. This has the advantage of giving absolute knowledge of true human productivity and make all values directly comparable without qualifications. The common denominator, called the "unit" or "Bedaux unit" corresponds to the standard productivity in one man-minute. It is such that the average group of men in temperate zones, properly trained and with reasonable direction and incentive, will eventually develop under normal working conditions an average productivity of 80 units per hour, when all items of waste are eliminated. Each Bedaux unit is made up of two parts: One, the element of work itself, and two, the rest allowance. The proportion of rest to work varies considerably according to the case, but the total always forms one unit, directly comparable and equal to any other Bedaux unit, whatever the work and whatever the circumstances. A productivity of one unit per man-minute, or 60 units per man-hour, is always standard. The expected average performance is therefore 33⅓ per cent above standard.

The Bedaux Standard

The Bedaux standard is the number, or fraction, of Bedaux units involved in the performance of a certain operation under certain conditions. It may be expressed per piece, per pound, or per whatever unit is indicated. Delays, wasted effort, and irregularities are not part of the Bedaux standards which remain free from these variable, nonproductive elements. Analysis of most human industrial operations requiring an effort expenditure shows that only a portion of the effort is translated into production. The other is nonproductive, unnecessary effort due to lack of skill or proper training or because improper conditions require additional work. The Bedaux standard is free of any such forms of waste and provides only for the best possible use of the facilities at hand in the best possible way.

Productivity Index

The relation "Bedaux units" to corresponding "man-hours" gives an index in terms of Bedaux units per hour, representing the true measure of productivity for the individual operator, group, plant, or industry. The index is directly comparable at all times with the standard of 60, the normal expectation of 80, and any other Bedaux index, regardless of operation or industry.

Application to Wage Incentive

Since the Bedaux standards measure the factor of productivity, base rates must be set to compensate for skill, working conditions, responsibility, and all factors other than productivity. This is usually done for the plant as a whole and insures the proper relationship of one job classification to another. Extra pay

starts when productivity reaches 60 Bedaux units per hour unless physical limitations or conditions necessitate the addition of legitimate allowances. Since the Bedaux unit standards do not include delays and losses, it is necessary to credit the producer with any and all losses of time beyond his control. Knowledge of these, in turn, guides management toward their elimination. The usual present practice is to calculate the extra pay at the rate of one minute's basic pay for each unit over standard, so that a performance averaging 80 units per hour receives additional earnings corresponding to 20 minutes per hour at the basic hourly rate.

The accuracy of the Bedaux standards and resulting basis of compensation permits a daily posting of individual performance wherever daily individual checking of production is feasible. This posting shows the productivity in terms of Bedaux units per hour and also corresponding earnings.

This description of the Bedaux method and principles shows that the first and basic aim is the study and knowledge of man's productivity. Along with many other truths, that knowledge of facts is not always palatable. It has at least the great advantage of putting a heavy finger on those spots that demand attention and correction and of making the correction ultimately profitable to all who are concerned.

Other Local Sections News

Anthracite-Lehigh Valley

Meeting in Berwick, Pa., on April 22, the Anthracite-Lehigh Valley Section heard Prof. F. G. Hechler, member, A.S.M.E., discuss, with the aid of slides, physical properties and tests of insulating materials. Following the talk, the motion picture "Heat and Its Control" was shown.

Atlanta

Eugene W. O'Brien, past vice-president of the A.S.M.E., at a meeting on May 2, described the trip which he took recently to the West Coast in connection with the Spring Meeting of the Society held in Los Angeles, Calif.

Baltimore

The May meeting of the Baltimore Section was appropriately called Ladies Night because each member brought a lady guest. The speaker was none other than Major Albert W. Stevens, U. S. Army Air Corps, who related his experiences in making several balloon ascensions which were culminated by his flight into the stratosphere to an official altitude record of nearly fourteen miles. The lecture was illustrated with colored slides and motion pictures. Then door prizes were distributed to the ladies.

Central Pennsylvania

A joint meeting was held by the section with the Altoona Engineering Society and the Centre County Engineering Society on May 4. W. M. Guynes, General Electric Co., gave a talk on "Railroading With Modern Power," and F. M. Graham, Pennsylvania R.R., presented a paper on "Dynamical Measurements of Movements and Stresses in Railroad Tracks."

Colorado

More than 230 members of the Colorado Section and the Colorado Society of Engineers turned out on April 12 to listen to Harvey N. Davis, President of the A.S.M.E., talk on "The Engineer and the Future."

Detroit

With James W. Parker, Vice-President of the Society, as toastmaster, a banquet was tendered to President Harvey N. Davis, on his visit to the Detroit Section on May 4. More than 250 members and guests turned out for the affair.

At a joint meeting held with the Detroit Engineering Society on April 20, about 750 members and guests listened to a talk on "Technology and Economic Progress," by Harold G. Moulton, president of the Brookings Institution. A story of the meeting and paper was reported in full in *The Detroit News* the next day.

Erie

The Erie Section held its annual joint meeting and ladies' night with the local chapter of the A.I.E.E. on May 17. John C. Page, member of the Federal Reclamation Commission, gave an illustrated lecture on the Grand Coulee Dam.

Ithaca

On April 22, speaking at a meeting held in Cornell University, Dr. E. J. Abbott, member, A.S.M.E., presented a paper on "Noises, Sounds, and Ears, and Their Relation to Machinery Quietness."

Kansas City

The Kansas City Section and its Junior Group met with the student branches of Kansas State College and of the University of Kansas at Lawrence, Kansas, April 21. Nominations for section officers for the coming year were made and elections will be held on or about May 26.

Louisville

Meeting at the University of Louisville on April 26, the members of the Louisville Section were privileged to welcome and to listen to a talk by Harvey N. Davis, President of the Society.

Mid-Continent

Monday, April 11, was a big day for the Mid-Continent Section. At a luncheon meeting, about 80 members and guests turned out to hear J. H. Wallace, vice-president and chief engineer of Pacific Enterprises, discuss counterbalance and flywheel relation in a pumping-well engine. Then at 6 o'clock in the evening, some of the members gathered for dinner at the Tulsa Club. Following the dinner, a meeting, held in the Mayo Hotel, was addressed by R. J. S. Pigott, Vice-President of the Society, on the "Theory of Lubrication Without Mathematics."

Milwaukee

L. H. Stark, chairman of the Milwaukee Section reports that the Student Group Meeting held in Milwaukee, April 18 and 19, was a great success, principally due to the inspiration furnished by the presence of President Harvey N. Davis. An attendance of approximately 250 student members from 17 schools indicated the great interest in the two-day session.

Nebraska

Members of the Nebraska Section had the extraordinary good fortune to listen to Dr. Harvey N. Davis, President of the Society, twice, according to A. A. Luebs, section secretary. The first talk on "Psychology in Industry" was given on April 14 before 300 in

AT THE MANAGEMENT CONFERENCE, IOWA CITY, APRIL 8

(The Tri-Cities Section of The American Society of Mechanical Engineers was one of the sponsors of a Management Conference held at the University of Iowa in Iowa City on April 8th. Two hundred and fifty plant managers and industrial engineers from twelve mid-western states attended the Conference. At the head table may be observed T. S. McEwan, chairman, Chicago Section, A.S.M.E., Lillian M. Gilbreth, A. H. Mogensen, Ralph M. Barnes, and H. O. Croft, all members of the A.S.M.E.)

Lincoln, Nebr. The second talk on "The Engineer and the Future" drew almost 100 at Omaha, Nebr., April 15.

New Haven

A fine time was had by all who attended the Connecticut Local Sections meeting at New Haven on May 11. The fine program was arranged by the General Committee, members of which were R. L. Parsell, chairman, T. H. Beard, H. E. Wells, R. D. Keller, Frank O. Hoagland (Vice-President of the Society), P. W. Bauer, M. L. Stevens, M. J. Radecki, E. Nibbs, E. S. Dennison, W. K. Simpson, and M. J. Dempsey.

Norwich

The last regularly scheduled meeting for the season of the Norwich Section was held on April 15. William Bolloy of Harvard University explained the "Use of Wind Tunnels in Aerodynamic Research." The talk was illustrated with motion pictures showing some of the wind tunnels which are used in Europe.

Philadelphia

"Latest Developments in Safe Flying and Landing" was the title of the talk presented by I. R. Metcalf, Bureau of Air Commerce, before the section on April 26.

Providence

At the April meeting of the Providence Section, William Staniar, member, A.S.M.E., discussed the choice of the correct mechanical transmission for various applications; 75 were present.

Rochester

Members of all of the engineering, architectural, and technical societies of Rochester, were the guests of the Rochester Section, A.S.M.E., at an annual dinner and dance held at the Oak Hill Country Club. The guest speaker was C. F. Hirshfeld, past vice-president of the Society and Worcester Reed Warner Medalist, who talked on "Technology and Economics."

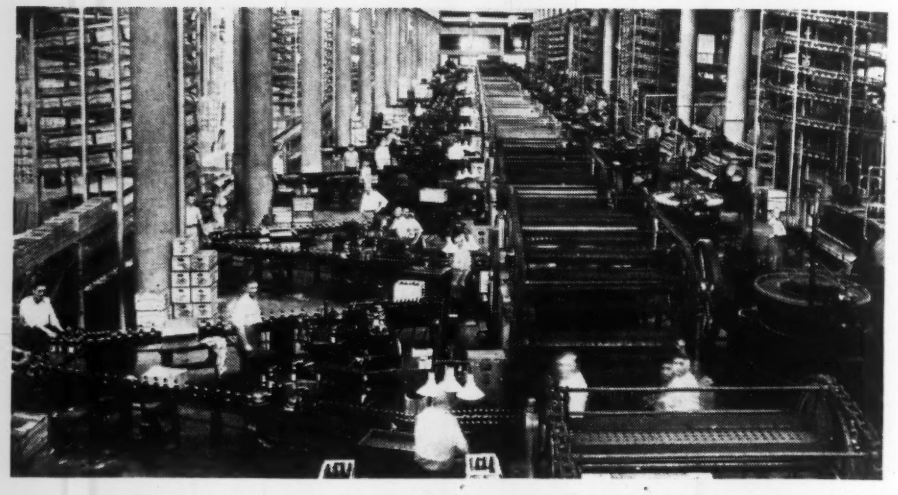
San Francisco

Approximately 100 members and guests attended the May 5 meeting of the Section at the Engineers' Club to hear a talk on "High-Pressure Steam Generators for Central Stations," by Henry Kreisinger, member, A.S.M.E., and engineer with the Combustion Engineering Co.

He gave a description of modern steam generators, burners of various types, superheaters and their applications, and discussed the desirability of high pressures and temperatures, and superimposition of high-pressure steam upon existing low-pressure plants. The paper was illustrated with slides showing the different kinds of apparatus and performance curves.

South Texas

An inspection trip was made by the members on April 29 through the plants of the Hughes Tool Company and the Gulf Brewing Co. in Houston.



AT THE BUDWEISER PLANT

(Part of one floor of world's largest bottling plant. Capacity: Three million bottles a day. It has 24 acres of floor space and 11 railroad tracks that can accommodate 55 freight cars in its basement. One of the 110 individual buildings that comprise the world's largest brewery. An inspection trip to this plant is planned during the A.S.M.E. Semi-Annual Meeting in June.)

Tri-Cities

A joint inspection trip followed by a meeting was held on May 3 at Cedar Rapids by the Tri-Cities Section with the student branches at Iowa State College and the University of Iowa. At the meeting, two Junior memberships in the Society, valued at $10 each, were awarded for the best paper presented from each school. Prizes of $5 each were presented for the second best papers.

Virginia

The Virginia Section was co-sponsor of a joint meeting at Norfolk, Va., April 29 and 30, with the local sections of the A.I.A., A.S.C.E., and A.I.E.E., and the Engineers' Club of Hampton Roads. Morning and afternoon technical sessions, a luncheon, and an informal dinner were held Friday. On Saturday morning, following a visit to the Naval Operating Base, members and their guests proceeded to the Seashore State Park picnic pavilion for lunch, having their choice of oysters, roasted or raw, ham, or barbecued pig. After lunch, some of those present hiked over the ten miles and more of trails in the park.

Washington

Members of the Washington Section were guests of the Baltimore Section on an inspection trip on May 7 to the Sparrows Point, Md., plant of the Bethlehem Steel Company. Of particular interest were the new 56-inch hot-strip mill and the new rod mill.

Waterbury

Hydraulic control of machines was discussed by W. Rouse and J. Farrington at a meeting on April 20.

West Virginia

On April 25, more than 100 members and guests made an inspection visit to the Huntington Works of the International Nickel Co. In the evening, W. B. Brown, assistant manager of the plant, gave a brief description of the works at a dinner held in honor of W. Z. Friend, the speaker for the meeting following the dinner. In his talk, Mr. Friend described the process of refining nickel and its alloys, gave the properties and characteristics, and illustrated their uses with the aid of slides.

Western Washington

Paul L. Heslop, member, A.S.M.E., and chief mechanical engineer on the Bonneville Dam project, at a meeting held on April 26 in Seattle, gave an illustrated talk on the Kaplan turbines, fish ladders, control gates, and gate controls being installed. Of interest was his description of the laboratory tests made to determine the shapes and sizes of the various parts used in the undertaking.

Worcester

Before the dinner meeting on April 13 at which H. E. Warren, president of the Telechron Clock Co., spoke on electric clocks, members and guests made an inspection trip through the company's plant at Ashland, Mass.

New England Engineers Reelect Officers

MEETING on April 20, representatives of the engineering organizations, including the Boston Section of the A.S.M.E., composing the Engineeering Societies of New England, reelected all officers for the year 1938-1939. Frederick W. Bliss is now serving his third consecutive year as president. Holcombe J. Brown, member, A.S.M.E., is first vice-president and James Holt, member, A.S.M.E., is one of the executive committeemen. Other officers are L. F. Jackson, second vice-president; J. Peterson, treasurer; H. C. Hamilton, secretary; and Albert Haertlein, executive committeeman.

Junior Group Activities

Problems of Graduates Told at Metro Meeting

"THE ENGINEERING Graduate's First Years in Industry" were discussed by Professor Frank L. Eidmann, of Columbia University, at the May 12 meeting of the Metropolitan Junior Group. Having recently completed a survey of 60 manufacturing companies in many fields, Professor Eidmann, long a student of the orientation problems of the young engineer, was in an excellent position to interpret the causes of the frequent failure of young engineering graduates to live up to the expectations of many employers. Pointing out that some of the blame can be placed on the college and industry also, the speaker emphasized that many of the difficulties were due to personality faults rather than to technical or educational weaknesses. He concluded with a list of pointers for getting over those first years in industry. The talk was published in May MECHANICAL ENGINEERING.

Elections

The Metropolitan Junior Group has re-elected W. G. Hauswirth as chairman; H. B. Fernald, vice-chairman; W. W. Lawrence, secretary-treasurer; S. Shoor and S. Davidson, members of the Executive Committee.

Talks to Students

Short talks on Junior Group activities and aims were made at three student branch meetings in the New York area recently, by E. A. Horner, of the Publicity Committee, Metropolitan Junior Group. Branches visited included City College, Newark College of Engineering, and Stevens Institute of Technology.

Air-Conditioning Seminar

The Air-Conditioning Seminar of the Metropolitan Junior Group closed its season's program with a talk on "Cooling Towers—Their Theory, Design, and Application" given by S. P. Brown, engineer, Research Corporation, May 3.

Discussing the different types of cooling towers available, the speaker emphasized the particular kinds of applications for which each is suited. He illustrated his points with lantern slides, and answered questions brought forward by the members in the discussion period.

South Texas Juniors Join in Greeting Dr. Davis

GUEST OF honor at a meeting of the South Texas Section and the Rice Institute Student Branch was Dr. Harvey N. Davis, President A.S.M.E. More than 75 engineers, students, juniors, and seniors, turned out to greet the President of the Society on his tour of the local sections and student branches.

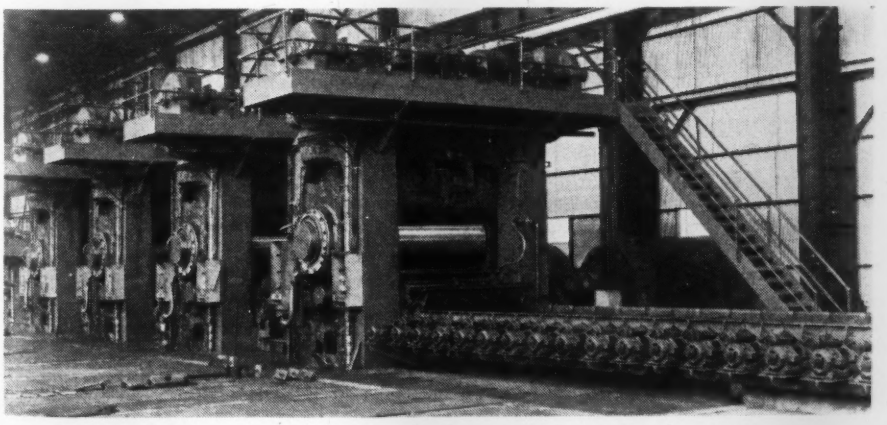
Taking as his theme "The Mechanical Engineer of the Future," Dr. Davis developed his talk in an extremely interesting fashion, illustrated with lantern slides. Everyone seemed to enjoy the discussion and a great number of questions were put to President Davis at the close of the meeting.

Immediately preceding the main meeting at Rice Institute, a dinner in honor of Dr. Davis was given at the Houston Club, attended by eleven members of the South Texas Section and three graduates of Stevens Institute.

Tri-Cities Juniors Sponsor Welding Meeting

RESISTANCE welding was the subject of a highly successful meeting sponsored by the Tri-Cities Junior Group and held at the Rock Island Arsenal Auditorium, April 27. More than 140 engineers attended, including members of the senior division, The American Society of Metals, and the National Association of Power Engineers. A special invitation had been extended to these organizations.

The speaker, F. H. Roby, of the Square D Company, discussed first the fundamentals of resistance welding, and the equipment usually employed. Pointing out that a large number of resistance welders use hydraulic cylinders to produce the necessary pressure, Mr. Roby described several control devices to insure the application of pressure before the welding current is allowed to flow. The operation of a mechanical welding timer was demonstrated by means of a cathode-ray oscillograph. Motion pictures illustrating various types of welding machines operating in automobile and implement plants were shown by Clyde Bassler of the Taylor-Winfield Co.



FINISHING STANDS, HOT STRIP MILL AT THE GRANITE CITY STEEL COMPANY
(To be visited during the A.S.M.E. Semi-Annual Meeting in St. Louis in June.)

Plan for Junior Session at Annual Meeting in December

A SESSION for Junior Members will be a feature of the Annual Meeting of The American Society of Mechanical Engineers in December. Plans are taking shape and it is hoped that a large number of visiting Juniors will attend the session and will exchange greetings and ideas.

The subject of the meeting is under consideration by a committee headed by Walter W. Lawrence, Junior Representative, Committee on Meetings and Program. He is assisted by R. F. Warner, Jr., chairman of the Program Committee, Metropolitan Junior Group, and L. F. Zsuffa, representing Society headquarters.

Juniors are invited to send suggestions to the committee, L. F. Zsuffa, A.S.M.E., 29 West 39th Street, New York, N. Y.

Talk on Testing Feature of Toronto Meeting

THE LAST regular meeting of the Toronto Junior Group, was featured, by a talk on "Worthwhile Mechanical Tests," by Forrest Nagler, engineer, Canadian Allis-Chalmers, Ltd. Describing many interesting tests, Mr. Nagler showed the importance of loading full-size vessels to destruction, to enable comparison between the theory of design and the actual mode of failure. Included with the talk was a demonstration of a small model of a rock crusher which is used extensively in Canadian mines.

The following officers were elected for the coming year: G. E. Smith, chairman; R. G. Gillespie, secretary-treasurer; J. B. Treloar, A. S. Foreman, and W. R. Trusler, members of the executive committee. In accordance with the policy of last year, H. G. Hill, retiring chairman, will sit on the executive committee in an advisory capacity. There will also be a representative from this year's graduating class at the University of Toronto, who will assist by encouraging participation in A.S.M.E. affairs.

Other Engineering Activities

46th Annual Meeting of S.P.E.E. at College Station, Texas, June 27–30

Prominent A.S.M.E. Members to Speak; F. L. Eidmann, Chairman of M.E. Division

FOLLOWING the Semi-Annual Meeting of the A.S.M.E. in St. Louis, the educators will gather up their notes, bags, and fishing poles, look up train schedules, and hie themselves to College Station, Texas, for the period of June 27–30, in order to take part in the forty-sixth Annual Meeting of the Society for the Promotion of Engineering Education, for convenience abbreviated to S.P.E.E.

If the professors, deans, and college presidents don't get the urge to play hooky so that they can go fishing or golfing, they will probably be present at the many worth-while general sessions and group conferences on all kinds of engineering courses, English, orientation of freshmen, etc. The following excerpts from the program should give to A.S.M.E. members, who plan to attend, an idea of the interesting sessions which have been provided for them.

Tuesday, June 28, 1938

Opening Session, S. B. Earle, member of Council, A.S.M.E., and president of S.P.E.E., presiding.

Welcome: F. C. Bolton, vice-president, A.&M. College of Texas. Response: S. B. Earle. Address: T. O. Walton, president, A.&M. College of Texas.

Presidential address: "The Cultural and Professional Phases of Engineering Education," by S. B. Earle.

"Professional Phase of Engineering Education," by A. A. Potter, past-president, A.S.M.E.

Wednesday, June 29, 1938

Second General Session, Cultural Phase of Engineering Education. J. W. Calhoun, president, University of Texas; D. S. Kimball, past-president, A.S.M.E., and dean emeritus, Cornell University; and Harvey N. Davis, President of the A.S.M.E. Discussion by A. F. Greaves-Walker, North Carolina State College, and C. W. Crawford, member, A.S.M.E.

Annual Dinner, S. B. Earle, presiding. Election of officers. Presentation of Lamme Medal.

Address by Karl T. Compton, member, A.S.M.E., and president of M.I.T.

Thursday, June 30, 1938

Third General Session, Professional Phase of Engineering Education. W. R. Woolrich, chairman of Local Sections Committee, A.S.M.E., and dean, University of Texas; Bradford Knapp, president, Texas Tech; and O. W. Eshbach, A.T.&T. Discussion by C. E. Davies, Secretary of the A.S.M.E., and Gibb-Gilchrist, dean, A.&M. College of Texas.

Mechanical-Engineering Division

Frank L. Eidmann, member, A.S.M.E., chairman, and Frank D. Carvin, member, A.S.M.E., secretary.

Monday, June 27. General session with F. L. Eidmann presiding. "Combined Engineering Laboratories in a Mechanical-Engineering Curriculum," by H. E. Degler, member, A.S.M.E. "Should a Thesis Be Required for a B.S. Degree in Mechanical Engineering," by L. M. K. Boelter, member, A.S.M.E. Discussion by J. J. Wilmore, member, A.S.M.E.

Reunion luncheon of those who attended Summer School for Mechanical Engineering at Purdue University in 1929. Everybody welcome, whether they attended the school or not. Talks by A. A. Potter, past-president, and C. E. Davies, Secretary of the Society.

Annual Dinner of the Mechanical Engineering Division.

Tuesday, June 28. Simultaneous sessions.

Heat power group. C. H. Berry, member, A.S.M.E., presiding. "A Survey of Heat Power Courses," by B. G. Elliott, member, A.S.M.E.

Joint session of machine-design group, manufacturing-processes group, and industrial-engineering group with A. W. Luce, member, A.S.M.E., presiding. "What the Machine Design Instructor Would Like His Students to Learn in Shop Laboratory Courses," by M. E. Begeman, member, A.S.M.E. "Interdependence of Shop Work and Methods Engineering," by A. S. Knowles, Northeastern University.

Mechanical laboratory group. J. W. Haney, member, A.S.M.E., presiding. "A Survey of Mechanical Laboratory Practice," by R. B. Rice, member, A.S.M.E.

S.P.E.E. Represented at St. Louis

The S.P.E.E. is to be officially represented at the A.S.M.E. meeting in St. Louis by its president, S. B. Earle, who is also a manager and member of the Council of the A.S.M.E.

E.C.P.D. Obtains Carnegie Grant of $10,000 to Prepare and Publish Review of Engineering Education

Dugald C. Jackson to Direct Project

SUPPORTED by a grant of $10,000 from the Carnegie Foundation for the Advancement of Teaching, the Engineers' Council for Professional Development has arranged for the preparation and publication of a "Report on Engineering Education in 1937." This will be based on the great amount of information which has been gathered by the E.C.P.D. Committee on Engineering Schools in connection with its investigation, for purposes of accrediting, of all the engineering curricula in the degree-granting institutions of the United States. The work will be in charge of Dugald C. Jackson, member, A.S.M.E., emeritus professor of electrical engineering at the Massachusetts Institute of Technology, and formerly president of the Society for the Promotion of Engineering Education, of the American Institute of Electrical Engineers, and of the Boston Society of Civil Engineers.

The information which will form the basis of this report has been gathered partly from the answers to extensive questionnaires from all of the engineering schools of the country, partly from other published material, and partly from the confidential reports by the committees which have inspected the engineering schools during the past three years. During the past year these committees of inspection traveled about 600,000 man-miles in connection with their inspections. The membership is representative of the seven national engineering groups which combine to form the E.C.P.D. These are: The American Society of Civil Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, American Institute of Chemical Engineers, American Institute of Mining and Metallurgical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners.

It is expected that the Report on Engineering Education for 1937 will be ready for publication within a year, and copies distributed to important engineering libraries and officials of the engineering schools and engineering societies.

V.D.I. Holds Annual Meeting in Stuttgart, May 27–31

THE 76TH Annual Meeting of the Verein deutscher Ingenieure was held in Stuttgart, May 27–31. Officially representing the A.S.M.E. at the meeting were Conrad Matschoss, life member, A.S.M.E., and Franz zur Nedden, member, A.S.M.E., who were appointed Honorary Vice-Presidents of the Society for the occasion.

On May 25 and 26, the Society of German Heating Engineers convened at Stuttgart. Following the V.D.I. meeting, the German Refrigerating Society met on May 30 and June 1.

A.S.M.E. to Be Represented at Glasgow Engineering Congress

REPRESENTATIVES of The American Society of Mechanical Engineers at the International Engineering Congress in Glasgow, Scotland, June 21–24, will be Geo. A. Orrok, honorary member, A.S.M.E., and George A. Stetson, member, A.S.M.E., and editor of the Society publications, who are making a vacation trip to Europe. As a contribution of the A.S.M.E. to the program, Mr. Orrok will present a paper on "The Central Station in One Man's Lifetime."

Engineers participating in the Congress will have an opportunity to visit the Empire Exhibition, the largest since Wembley, which opened last month and will continue until October. Members of the A.S.M.E. who plan to attend the Congress are asked to communicate with the Secretary of the Society so that he may send their names to the proper officials.

Tentative Program Ready for Management Congress

IN VIEW of the world-wide complexities confronting management today, those responsible for the program of the Seventh International Management Congress, to be held in Washington, D. C., Sept. 19–23, decided that such an international gathering can render its greatest service by devoting itself not only to the advancement of management practice but also to the promotion of a better understanding of the economic and social forces affecting business enterprise in present-day society. Accordingly the program includes both general and technical sessions.

General Sessions

At the general sessions, addresses will be given in pairs to introduce the American and foreign points of view on social and economic aspects of management. It is expected that these addresses will help to clarify the broader responsibilities of management and provide a basis for judging current management practices as described in the papers to be discussed at the technical sessions.

No Presentation of Papers

The six series of simultaneous technical sessions will provide for a discussion of recent developments in management techniques, pertaining separately to administration, production, distribution, personnel, agriculture, and the home.

There will be no papers presented orally. All papers will be preprinted with provocative critiques and supplied to registrants. In this way the full time of the sessions will be devoted exclusively to discussion. All these technical sessions will culminate in a final assembly where the chief rapporteurs will summarize the discussion in the respective sessions.

PLANT OF LACLEDE-CHRISTY CLAY PRODUCTS COMPANY
(On the program of plant trips for the A.S.M.E. Semi-Annual Meeting in St. Louis in June.)

A.S.M.E. Participates in Franklin Ceremonies at Philadelphia

AT THE UNVEILING of a statue of Benjamin Franklin in front of the Franklin Institute in Philadelphia, on May 19, the Society was officially represented at the ceremonies that day and at the lecture on pure science the following day by Conrad N. Lauer, past-president, A.S.M.E. On May 21, Harvey N. Davis, President of the Society, besides representing the A.S.M.E. in his official capacity, also delivered a talk on applied science. Another speaker on the same program was W. E. Wickenden, member, A.S.M.E., and president of the Case School of Applied Science. The A.S.M.E. member of the Applied Science Committee, in charge of arranging the last day's program, was Nevin E. Funk.

On May 20, Dr. William F. Durand, past-president of the A.S.M.E. and professor emeritus of mechanical engineering at Stanford University, was awarded the Franklin Medal of the Franklin Institute for distinguished work in physical science.

Photoelasticity Conference Held at Harvard

ON MAY 14, the Eastern Photoelasticity Conference held its seventh semi-annual meeting at Harvard University. Some of the subjects covered at the session included teaching methods, texts, polarizers, research projects, plasticity, three-dimensional photoelasticity, and indeterminate structures. Chairman of the executive committee for the conference is R. W. Vose, member, A.S.M.E., and among the members is M. L. Price, member, A.S.M.E.

Stevens Sponsors Annual Economics Conference

MEETING at the Stevens Engineering Camp, Johnsonburg, N. J., the eighth Annual Economics Conference for Engineers will be held from June 24 to July 2. This year's Conference will be sponsored jointly by Stevens Institute of Technology and the Society for the Advancement of Management. The Conference will be divided into six sections—four sessions daily through the week on motion and time study, human relations, marketing, industrial management, and management problems.

One section will serve as a round table for teachers of management. The afternoons will be devoted to informal conferences and recreation.

Fuels Division Gives Smoke-Prevention Meeting Paper

THE Thirty-Second Annual Convention of the Smoke Prevention Association was held in Nashville, Tenn., May 17–20. The Fuels Division of the A.S.M.E. was represented by its secretary, A. R. Mumford, who presented at one of the sessions a paper on "Some Aspects of the Smoke and Dust Problem."

Edison Electric Institute Meets in Atlantic City, June 6–9, 1938

THE SIXTH Annual Convention of the Edison Electric Institute will be held in Atlantic City, N. J., June 6 to 9, 1938. All of the business sessions will be held in the ballroom of the Convention Hall.

American Engineering Council

Presents

The News From Washington and Elsewhere

Public Affairs Forum

FIRST of a series of regional meetings to be sponsored by the Public Affairs Committee of the American Engineering Council was held on Friday, May 13, at the Engineers' Club in Philadelphia. These forums are expected to promote a wider public understanding of the interrelation between engineering and the vexing social and economic questions of the day. Comment on this first forum is made in this issue of MECHANICAL ENGINEERING on page 462.

Government and Engineering

Upon the request of the mayor and city manager of Fort Worth, Texas, and the Lower Colorado River Authority, the Federal Power Commission has consented to make a preliminary estimate of cost of an electric distribution system for the City of Fort Worth and a forecast of the power requirements of that city during the next decade. Since the announced intention of the F.P.C. indicated federal government competition with engineers in private practice against the general public welfare; and in response to a number of inquiries, the staff of Council interviewed the Commission. Acting Chairman Clyde L. Seavey assured Council that the Federal Power Commission has no intention of engaging in any business or professional activity in competition with private industry or with engineers in private practice.

Congressman Champions Technology

Congressman Jennings Randolph of West Virginia, who looks upon technology as the nation's greatest resource, has informed Council's staff that he already has hundreds of letters of commendation from listeners to his coast-to-coast broadcast on April 12 in which he again championed the cause of technology and referred favorably to the address he made before the A.E.C. in January, 1938. He reports encouragement from engineers, investment brokers, industrialists, and from professional and business people in all parts of the United States.

Salary Standardization

G. L. Sullivan, chairman of the San Francisco Section, A.S.M.E., as chairman of a special committee of the S.F. Engineering Council cooperating with the Civil Service Board of the city in a study of salaries, job specifications, etc., of civil-service positions, recently released a report of the committee's recommendations. The committee believes that working conditions, which include salary, vacations, sick leave with pay, and opportunities for advancement according to merit, should be such as to attract and hold the highest type of engineering personnel. Starting salaries should be in agreement with prevailing normal rates and the range in the classification should be wide enough to permit of salary increases in accordance with experience and efficiency.

Included in the report is a classification of positions covering seven grades with salaries ranging from $110 to $650 per month. The lowest grade is included to take care of those subprofessional positions that are commonly filled by junior engineers just out of college. Positions paying over $650 per month are not included because their importance warrants individual study.

Engineer-Employer Negotiation

Following instructions of the members at the annual meeting, the Iowa Engineering Society has created a new department devoted exclusively to the welfare and economic status of the employed engineer. Service will be rendered to participating engineers upon payment of a membership fee of $5 and an annual due of $12 for the first year. According to Secretary-Treasurer J. S. Dodds, membership in the society is not required in order to subscribe to the department's service. He says, "It is the intention to have one or more full-time field men employed to represent the engineers in their relation with their employers and it is hoped that some of the situations in connection with engineering employment in the state may be improved by negotiations."

Council remarks that this professional approach by a fifty-year old professional engineering society to the problem of helping the engineer improve his economic status will be followed with interest by all engineers.

Coal Commission Digest

Believing that the interests of bituminous-coal consumers can be served more efficiently by a closer cooperation and regular contact, the Office of Consumers' Counsel, National Bituminous Coal Commission, P.O. Box 483, Washington, D. C., has inaugurated a new bulletin, *Coal Consumer Digest*. It is the aim to present in the *Digest* information on the work of establishing new minimum prices by the Commission, analyses of marketing rules and regulations, and other pertinent data of interest to consumers. Frequent reports on the activities of the Commission also will be published. Members of the A.S.M.E. will be placed on the mailing list upon request to the above address.

R. I. Registration Law

Rhode Island became the fortieth state to adopt an engineers' license law when the governor of the state signed the registration bill on April 23, 1938.

New Private Flyers' Bureau

TO ENCOURAGE and stimulate all phases of private flying, a Private Flying Section of the Bureau of Air Commerce was established in April, according to an announcement by the Department of Commerce. The new section will determine and analyze the problems of the private flyer and will guide the Bureau in its regulations affecting this branch of aviation.

Based upon an extensive survey of present aeronautical needs and expected future developments, Report No. 7, "Development of a Safety and Planning Program" by the Safety and Planning Division of the Bureau of Air Commerce, is a comprehensive analysis of routine and special projects now in progress, or under consideration, dealing with the advancement of civil aviation. This complete report is now available for public distribution.

(*A.S.M.E. News continued on page 522*)

THE LACLEDE GAS LIGHT COMPANY BY-PRODUCT PLANT

(A plant to be inspected during the A.S.M.E. Semi-Annual Meeting in St. Louis in June.)

The Lincoln Tunnel FANS SKF-EQUIPPED

HERE'S one of 36 SKF-equipped direct-driven fans, built by Buffalo Forge Company, each weighing approximately 10 tons, which ventilate the Lincoln Tunnel.

When the New York Port of Authority wrote specifications for bearings on these fans, it did so with a mind toward getting *minimum maintenance, absolute reliability and long life* with *no lubricant leakage and no necessity for adjustments.*

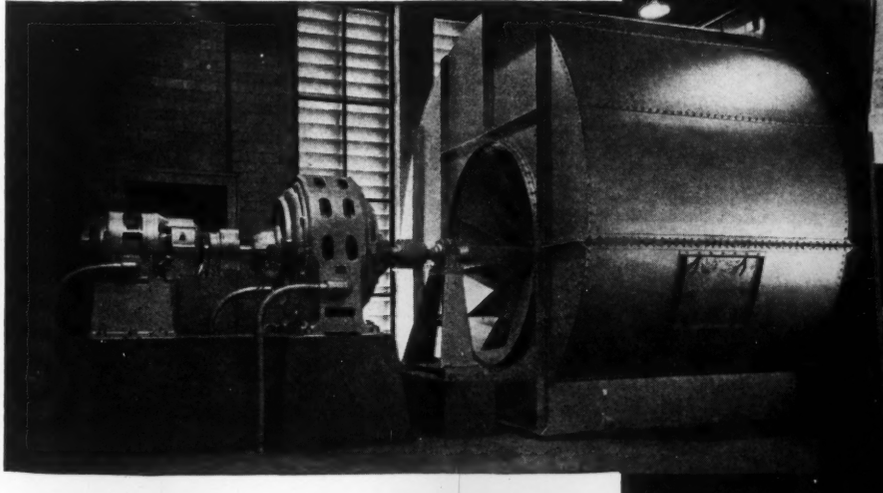
In practically every large and important engineering endeavor where reliable performance is desired, you will find SKF Bearings assuring dependability.

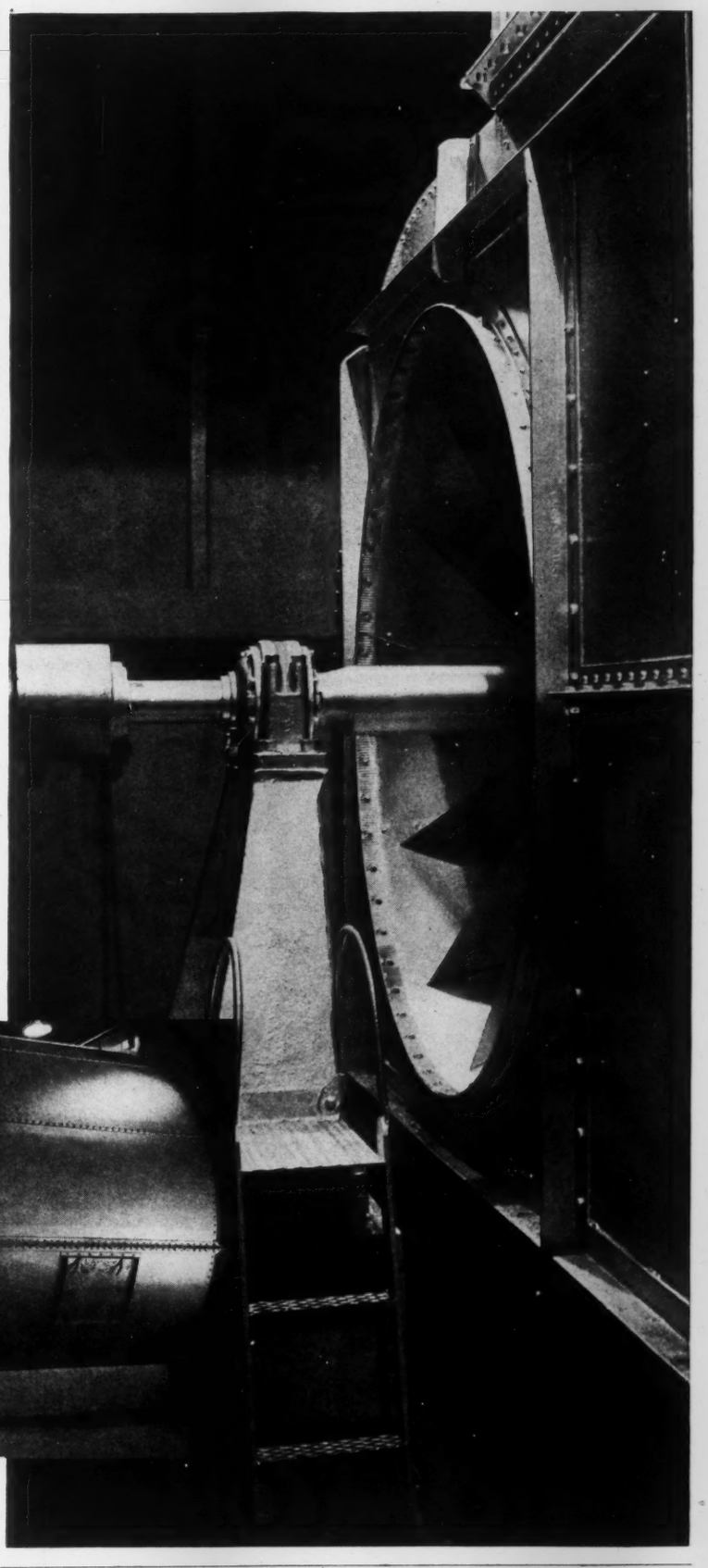
SKF Bearings can be depended upon to lower power, maintenance and lubrication costs in every installation. As they do it here, they will do it on *your* machines. 4086

SKF INDUSTRIES, INC., PHILA., PA.

SKF

BALL & ROLLER BEARINGS





● *Close-up of blower fan, one of 36 built by Buffalo Forge Co., for Lincoln Tunnel ventilation.*

Men and Positions Available

Engineering Societies Employment Service

MEN AVAILABLE[1]

PLANT ENGINEER, graduate, M.E., 46, married; 18 years' experience design, construction, maintenance of industrial power plants; 8 years plant engineer. Available responsible connection. Chicago. Me-67-9427.

JUNIOR M.E., graduate University of Florida, 1936; experience in time study, production control, machine shop; desires position small, medium-size plant in East. Me-68.

EXECUTIVE ENGINEER, 30 years' wide experience economic production, plant utilization of steam and electric power. Utility transmission, distribution. Available reasonable notice as plant or maintenance engineer, or utility executive. Me-69.

MECHANICAL ENGINEER 37; 12 years' design experience in chemical, oil refinery, power plants. Practical machine-shop experience. Seeks permanent connection. Me-70.

MECHANICAL ENGINEER AND DESIGNER experienced in construction and maintenance chemical and industrial plants. Design of equipment, piping, heating and ventilating, machinery and tools. Checking, purchasing. Seeks position Metropolitan New York. Me-71.

MANUFACTURING EXECUTIVE. Experience in managerial, supervisory capacity. All phases factory administration, production, design, factory layout, purchase experience machine tool, printing press, automotive, railroad products, forge shop, foundry, industrial management; development work. Me-72.

MECHANICAL ENGINEER 43, married; 19 years' experience, assistant to chief engineer, assistant superintendent manufacturing, superintendent inspection. Thorough mechanic, well versed in all branches of small interchangeable manufacturing. Me-73.

SUPERINTENDENT, 40, married; 18 years' varied experience operation, maintenance steam power plant, including latest system water treating for high-pressure boiler plant; factory training, specialized power-plant engineering recognized engineering college. Me-74.

MECHANICAL ENGINEER, graduate Lehigh, 1936. Experience in aircraft tooling, bakery, chemical, grinding mill, and drier-machinery design. Available design or sales-engineering position. Me-75.

ASSISTANT PROFESSOR MECHANICAL ENGINEERING, S.B., M.S., married. Thermodynamics, strength of materials, applied mechanics, mechanical-engineering laboratory, machine design, internal-combustion engines. Location preferred, New England. Me-76.

MECHANICAL ENGINEER, graduate 1927; 3 years' experience operation, erection, maintenance work; 1 year's experience estimating, sales correspondence; 1 1/2 years' experience drafting and design, in air conditioning, and refrigeration field. Me-77.

MASTER MECHANIC, 30 years in tropical Latin America. Practical experience machine-shop supervision. Maintenance rolling stock for mountain railroads. Power-plant equipment and refrigeration. Speaks Spanish. Available immediately. Me-78.

MECHANICAL ENGINEER, 25 years' experience; 15 in responsible charge of development of hydraulic machinery, hydraulically powered machine tools and equipment, press tools, industrial furnaces, gaging systems. Good practical shop executive. Me-79.

MECHANICAL ENGINEER, 24, Penn State 1934; experienced in lock industry as assistant to superintendent, also in agricultural engineering field. Prefers work machine-tool, refrigeration, firearms, or automotive field. Me-80.

MECHANICAL ENGINEER, M.Sc. 1936, seeks technical, commercial, or academic work in foreign lands. Me-81.

MECHANICAL ENGINEER, recent graduate, M.E. degree. Young, aggressive. Experienced in specification work. Particularly interested in design. Desires permanent position with large organization. Travel anywhere. Me-82.

MECHANICAL ENGINEER, 39, four years power plant; 12 years asphalt-roofing plant. Experience: general plant-engineering problems, product design and application, reports, correspondence. Desires position plant engineer or executive assistant. Me-83.

MANUFACTURING EXECUTIVE, thoroughly familiar with every phase of factory management and production. Graduate industrial engineer, 15 years' experience in consulting field and as manufacturing executive and production manager. Age 37. Me-84.

MECHANICAL ENGINEER, 1936 graduate of Armour Institute; experience with piping and equipment contractor; desires position with manufacturer; no objection to location or hours. Me-85.

MECHANICAL ENGINEERING GRADUATE of Massachusetts Institute of Technology, 1921, two years' public-utility valuation; 4 years' mechanical research; 10 years' sales engineering in machinery field; 1 year as executive in manufacturing. Me-86.

GRADUATE MECHANICAL ENGINEER, 35. Nine years' experience mechanical-design problems, diagnosing mechanical failures. Stress analysis, vibration study, and production engineering, principally in electrical apparatus. Adaptable. Initial salary unimportant. Me-87.

ENGINEER, 41, married; technical school graduate. Experienced production planning, tooling of nonferrous sheet-metal products, including cost estimating routing, computing machine hours; also drafting. Desires connection progressive concern. Me-88.

EXECUTIVE ENGINEER seeks connection developing new mechanical products. Many years' responsible experience design and manufacture, particularly internal-combustion engines, compressors, related machinery. Capable in other lines as well. Cornell graduate. Me-89.

DRAFTSMAN-DESIGNER, M.E. graduate, 36, married. Thirteen years' experience design of automatic machinery for cans and containers, hydraulic machinery, tools, and fixtures. No geographical preference. Me-90.

MECHANICAL ENGINEER, 29; married. One and one-half years' production planning and manufacturing development; 2 years' petroleum laboratory; 3 years' research in carburetion development. Ability to originate, design, and develop. Me-91.

MECHANICAL GRADUATE, 1937; 21. Six months' production drafting of steel fabrication; 3 months' development design of circuit breakers for leading electrical concern. Me-92.

MECHANICAL ENGINEER, honor graduate, 25, single. Three years' experience in research and development. Turbines, internal-combustion engines, and heat-transfer apparatus. Will start from bottom for eastern manufacturer or public utility. Me-93.

DRAFTSMAN-DESIGNER, licensed professional engineer. Twenty years' drafting, teaching, and shop experience. Steam turbines, heavy and light machinery and tools. Structural and product design. Plant layouts. Development engineer, food industries. Me-94.

MECHANICAL ENGINEER with extensive executive experience in manufacturing engineering, development and sales of semiautomatic machinery. M.I.T. training. Wants position as chief engineer, chief draftsman, or sales engineer. Me-95.

POSITIONS AVAILABLE

PRODUCTION ENGINEER with experience in production heavy machinery. Thorough knowledge of printing presses preferred. Apply by letter. Location, East. Y-2902.

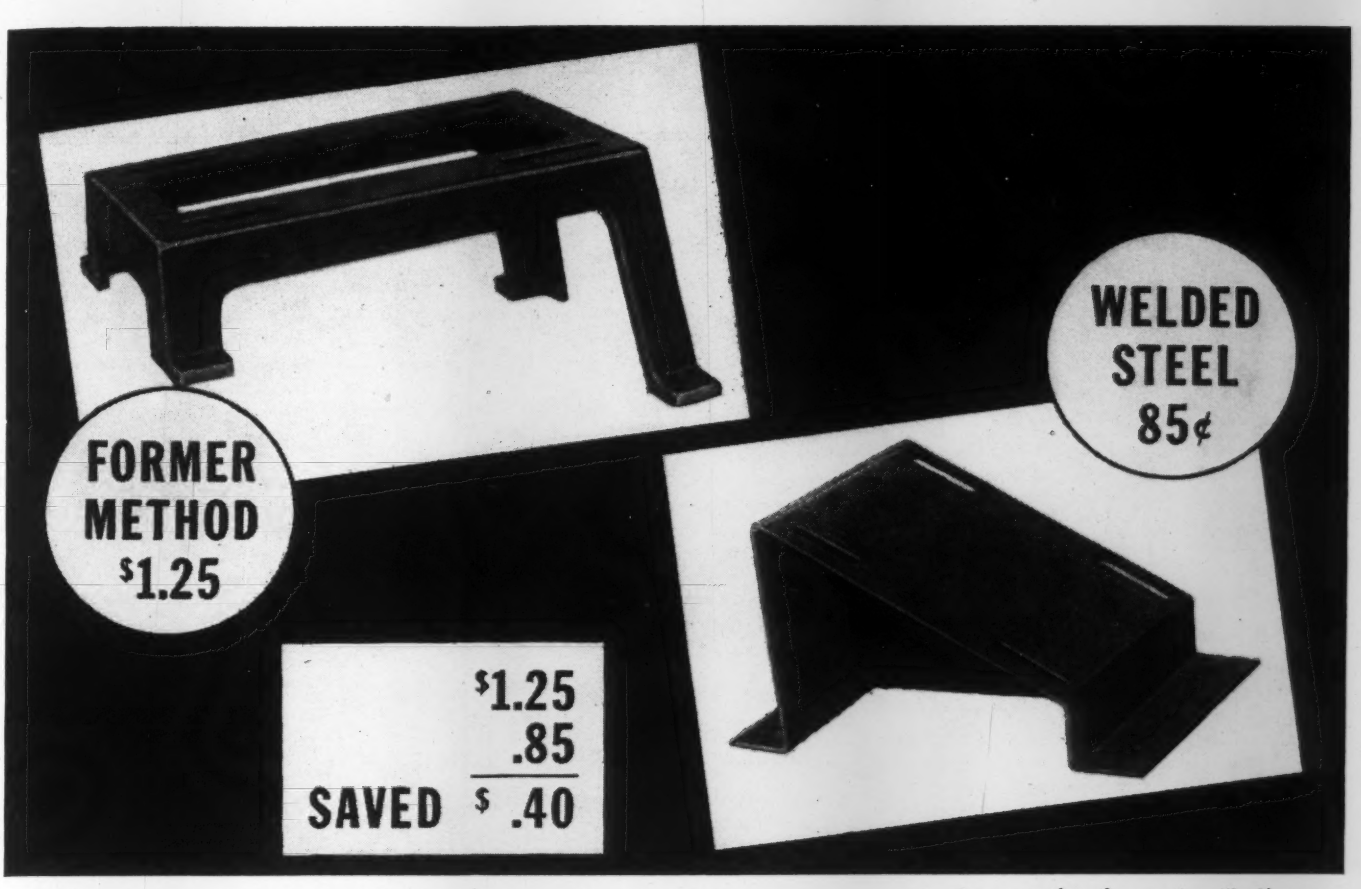
QUOTATION ENGINEER, 35–40, with at least 5 years' experience manufacturing heat-transfer products, such as heat exchangers of all kinds, coolers, evaporators, condensers, fuel-oil heaters. Apply by letter. Location, New Jersey Y-2907.

SUPERINTENDENT, about 40, graduate mechanical engineer for machine shop. Must have broad experience manufacture of machine tools. Require executive who has worked in shop on problems encountered in medium or large machine tools. Salary, $400 a month. Apply by letter. Location, East. Y-2915.

CHEMICAL OR MECHANICAL ENGINEER, 25–40, with at least 5 years' manufacturing-plant experience, preferably in design of machinery and chemical-plant equipment. Should have good personality; will be required to consult with purchasers of company's equipment. Salary, $250–$400 a month. Apply by letter. Location, New York State. Y-2921.

(*A.S.M.E. News continued on page 524*)

[1] All men listed hold some form of A.S.M.E. membership.



A generator base for a grain mill. Changeover to welded steel saved 40c each, cut weight 55%.

YOU *PROFIT* BY MANUFACTURING WITH WELDED STEEL BECAUSE:

1. Rolled steel construction cuts weight 30% to 60%.

2. Rolled steel saves 50% to 75% in cost per pound.

3. Rolled steel is 2 to 3 times stiffer, 3 to 6 times stronger in tension, and is perfectly uniform, dependable.

4. In shielded arc welded steel construction you get physical properties equal or superior to mild rolled steel.

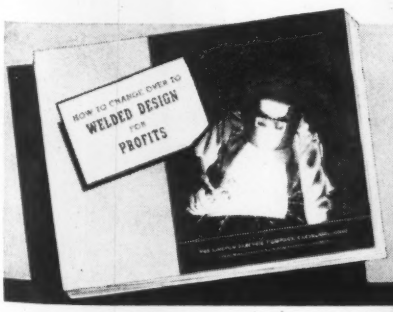
5. Welding cuts design costs, eliminates patterns, eliminates waste due to defects, minimizes machining.

6. Welded designs are more modern in appearance, increasing saleability.

Start now to get the profits of welded steel manufacturing. Write for the book, "How to Change Over to Welded Design." It gives valuable suggestions from executives and engineers of scores of plants.

THE LINCOLN ELECTRIC CO., Dept. T-483, Cleveland, Ohio

Largest Manufacturers of Arc Welding Equipment in the World



MR. G. F. THOMAS, *Vice President*
Prater Pulverizer Co., Chicago, Ill.
says—"In addition to having greater engineering freedom in the manufacture of our pulverizing equipment, we have experienced maximum economy through the use of welded steel construction."

MECHANICAL ENGINEER, graduate of university of recognized standing. Engineer preferred with experience in automobile field in Middle West and in high-speed production. Must be able to decide if tool and die engineer is following proper procedure in designing; if research engineer is correct in mechanical ideas. Competent to survey and suggest remedies to improve inefficient operation in departments. Experience small assembly work, iron and brass foundry, pressroom work required. Apply by letter. Location, East. Y-2934.

INSTRUCTOR, young, preferably single, for experimental - engineering laboratories. To teach steam and internal-combustion engines, materials testing, hydraulics, etc. Salary, $1800 for college session of nine months, paid monthly. Apply by letter giving complete statement experience, background, and enclosing recent photograph. Location, South. Y-2936.

ENGINEER with considerable experience in handling of gases and high pressures used in manufacture of dry ice. Apply by letter. Location, Middle West. Y-2937C.

MECHANICAL ENGINEER, 35–40, to act as superintendent of maintenance for large group of buildings. Must be thoroughly familiar with building construction, elevators, air-conditioning equipment, etc. Salary, $5000–$6000 a year. Apply by letter. Location, New York, N. Y. Y-2945.

MASTER MECHANIC with degrees in mechanical and mining engineering. Must have considerable practical experience in maintenance and operation of mining and milling properties, and ability to instruct others how actually to lay out and perform difficult jobs. Plant mills 1500 tons a day, with small smelter with waste-heat power as well as Diesel equipment. Salary, $350–$500 a month plus traveling expenses. Will be allowed six-month vacation period at termination of a three-year contract. Apply by letter. Location, Southwest Africa. Y-2946.

DIESEL ENGINE DESIGNER with experience in oil-field type of two-cycle oil and gas engines, varying in size from 7 × 9 twin verticals operating at 500 to 800 rpm up to 16 × 18 twin engines operating at 250 rpm, both using Bosch injection. Essential that applicant have good technical background and actual experience in designing such equipment. Apply by letter. Location, Pennsylvania. Y-2948.

INSTRUCTOR OR ASSISTANT PROFESSOR, about 30, with background of training and experience in modern power plants and experience in teaching. An advanced degree desirable, but not essential. Opportunity for advancement. Salary, $2500 for ten-month year. Appointment will start September, 1938. Apply by letter. Location, East. Y-2953.

DESIGNER with wide experience in pressed-steel work. Company is converting a number of its cast parts into steel pressed parts, and requires engineer to design press work with due regard for low-cost die making. Apply by letter. Location, New York State. Y-2955.

DESIGNING ENGINEER with broad experience in conveying machinery and equipment. Must have inventive ingenuity, as position requires the development of systems to meet specific requirements. Must also be capable of calculating stresses of any and all kinds in interest of simplicity of construction and saving of weight, yet leaving adequate strength. Apply by letter. Location, New York State. Y-2956.

SHOP SUPERINTENDENT, not over 40, with experience in dies, machine tools, etc. Engineer with experience with metal barrels preferred. Apply by letter. Location, New York, N. Y. Y-2958.

MECHANICAL ENGINEER, 35–40, with 3–4 years' practical experience in maintenance of boilers, stokers, refrigerating and air-conditioning apparatus, pumps, compressors, etc. Will be required to make industrial-plant surveys on mechanical equipment. Should have experience in Orsat tests, flue-gas analysis, indicator cards, etc. Some traveling in the eastern area. Apply by letter. Headquarters, New York, N. Y. Y-2962.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after June 25, 1938, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references.

Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Rt = Reinstatement Re = Reelection
Rt & T = Reinstatement and Transfer to Member

NEW APPLICATIONS

For Member, Associate, or Junior

CARRILLO, A. C., San Francisco, Calif.
CHINN, GEORGE C., Baltimore, Md.
CRESSON, WILLIAM J., JR., Swarthmore, Pa.
DI TULLIO, LOUIS, New York, N. Y. (Rt)
DREW, THOS. B., Wilmington, Del.
GAISMAN, HENRY J., Hartsdale, N. Y.
GILLIM, WILLIAM GATES, New York, N. Y.
HANSEN, SAM S., Los Angeles, Cal.
HAYES, JOS. I., Bronx, N. Y.
HOLLENSBE, H. E., St. Joseph, Mich.
LANG, L. F., Chicago, Ill. (Rt)
LEWIS, DARTREY, Boston, Mass.
LINDLEY, KEITH, Tulsa, Okla.
MILLIGAN, ROBERT GALT, New York, N. Y.
MITCHELL, A. L., JR., Chicago, Ill. (Rt & T)
MODROVSKY, JOSEPH, New York, N. Y.
MORGAN, CHAS. C., St. Louis, Mo.
MUNCKE, L. R., Detroit, Mich.
MUTZ, W. E., Chelsea, Mass. (Rt)
PEYSER, LEONARD F., Mt. Vernon, N. Y.
PHILLIPS, RAYMOND H., New York, N. Y.
PODOLSKE, T. A., Rochester, Minn.
POTTER, LINN EDWARD, Syracuse, N. Y.
REESE, HERMANN, Brooklyn, N. Y.
ROGERS, WALTER E., Shelton, Wash.
RUMFELT, HENRY F. C., Fort Peck, Mont. (Rt)
SHEPPARD, JOSEPH R., Chicago, Ill. (Rt)
STEPHENSON, REVIS L., Elmhurst, N. Y.
SUNDSTROM, JOHN V., St. Louis, Mo.
SUTHERLAND, JAS. E., Newark, N. J.
TAYLOR, A. H., Newton, Iowa
THOMAS, ROBERT L., Milwaukee, Wis.
TONGUE, HAROLD, Teddington, Middx., England
TODD, JOHN V., Tulsa, Okla.
VAN GORDEN, C. LEROY, Franklinville, N. J.
ZIEBOLZ, HERBERT, Chicago, Ill.

APPLICATIONS FOR CHANGE OF GRADING

Transfers to Member

ARTHUR, THEODORE S., Broadalbin, N. Y.
DAVIDSON, PHILIP, Pullman, Ill.
GONZALEZ, E. D., Banes, Oriente, Cuba
GREGORY, WILLIAM BRES, Dallas, Tex.
GRISWOLD, NELSON D., Marquette, Mich.
LARKIN, WILLIAM H., Staten Island, N. Y.
LOWTHER, GEORGE W., Newgulf, Tex.
PARKINSON, RUSSELL W., Jackson, Mich.
WINGREN, R. M., College Station, Tex.

A.S.M.E. Transactions for May, 1938

THE May, 1938, issue of the Transactions of the A.S.M.E., contains the following papers:

Combustion of Pulverized Coal (FSP-60-8), by Henry Kreisinger

Design of Flanged Joints for Valve Bonnets (FSP-60-9), by J. D. Mattimore, N. O. Smith-Petersen, and H. C. Bell

Tests of Heat-Exchanger Flanges (FSP-60-10), by D. B. Rossheim, E. H. Gebhardt, and H. G. Oliver

Carbonaceous Zeolites—An Advance in Boiler-Feedwater Conditioning (FSP-60-11), by H. L. Tiger

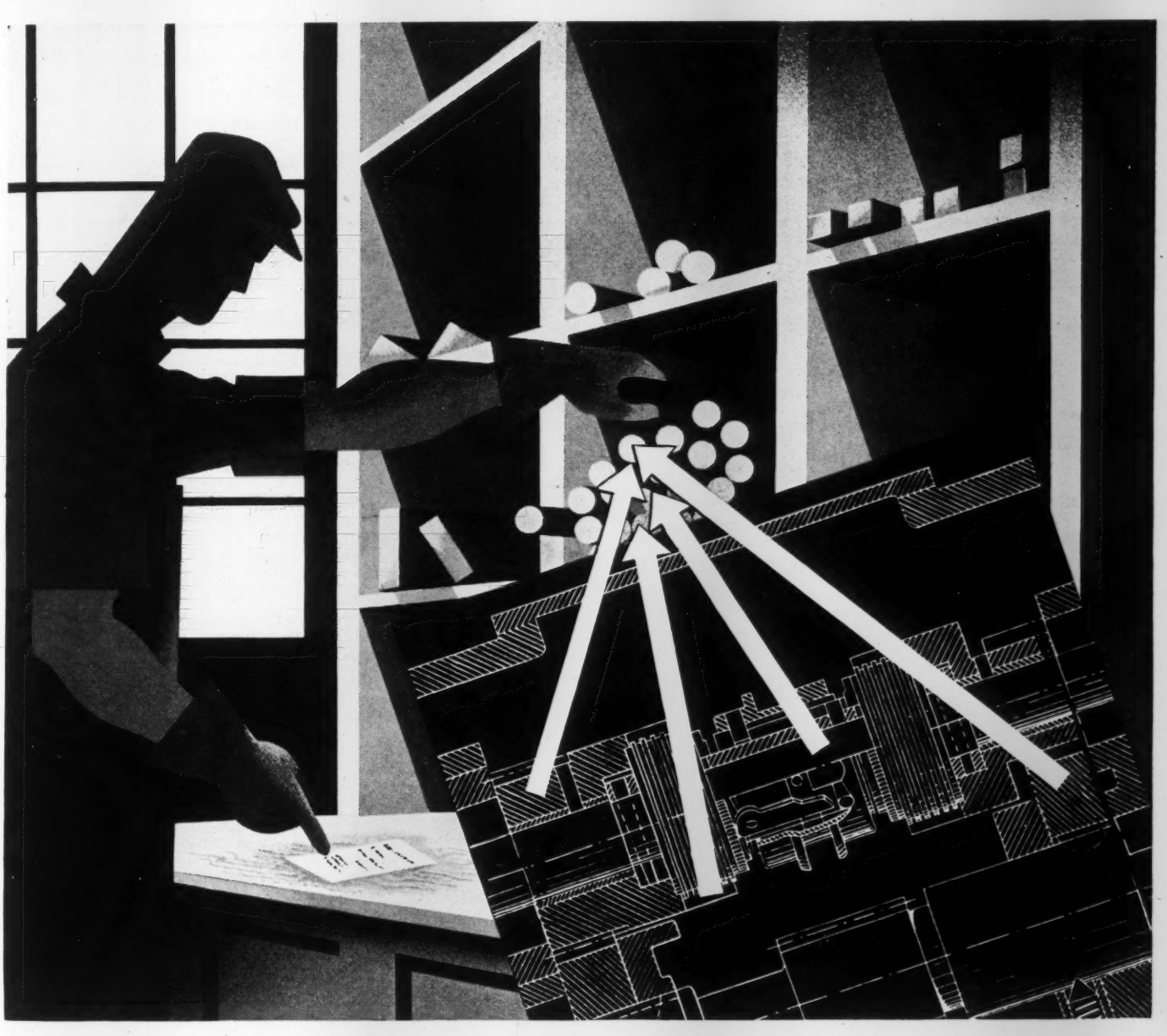
Quantitative Analysis of Process Lags (PRO-60-1), by C. E. Mason

Locomotive Axle Testing (RR-60-2), by T. V. Buckwalter, O. J. Horger, and W. C. Sanders

Influence of Pressure on Film Viscosity in Heavily Loaded Bearings (RP-60-7), by S. J. Needs

DISCUSSION

On previously published papers by G. Anbro; B. M. Guthrie; B. E. Tate; J. E. Tobey; A. D. Andriola; K. J. DeJuhasz; W. F. Joachim; C. G. A. Rosen; O. L. Pierson; E. D. Grimison; and E. C. Huge



MANY PARTS . . . ONE STEEL

SPECIALIZATION has its spheres, but in a manufacturing material ***versatility*** usually has the advantage. For instance, a truly versatile steel — one that can be made to meet the individual requirements of different applications — offers economies and shop efficiencies obviously impossible with a multiplicity of types.

One company building machine-shop equipment has standardized on a Chrome-Manganese-Moly steel for a great variety of parts. It was selected because it can be heat treated to a high hardness and still remain readily machinable.

Versatility is a feature of Moly steels in general. It reduces the chances of error by simplifying stock-room procedure and inventories; permits greater standardization of processes; assures more uniform results; and is an important factor toward economy.

The wide range of applications of Moly steels has been definitely proved in laboratory, shop and field. Our book, "Molybdenum in Steel," offers a quick technical survey of their scope. We invite engineers and production executives to write for it. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

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Available literature may be secured by addressing a request to the Advertising Department of MECHANICAL ENGINEERING or by writing direct to the manufacturer and mentioning MECHANICAL ENGINEERING as the source.

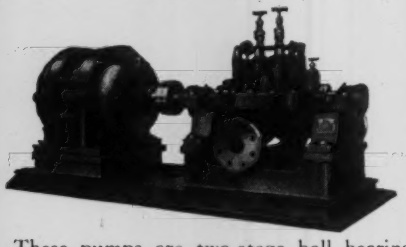
- ***NEW EQUIPMENT***
- ***BUSINESS CHANGES***
- ***LATEST CATALOGS***

Announcements from advertisers in MECHANICAL ENGINEERING and the MECHANICAL CATALOG

• *NEW EQUIPMENT*

Cameron Two-Stage Centrifugal Pumps

A new bulletin giving complete specifications and operating characteristics of the Cameron Class GT two-stage centrifugal pump has recently been issued by the Ingersoll-Rand Company.



These pumps are two-stage ball bearing units designed to operate at modern motor, turbine and engine speeds. They are available in capacities from 100 to 2200 gallons per minute for discharged heads up to 800 ft. (350 lbs. per sq. in.)

Two pages of typical installations of these pumps are pictured in the bulletin, number 7067, copies of which may be obtained from the Ingersoll-Rand Company, 11 Broadway, New York, N. Y., or any of their branch offices.

New Self-Supporting Pillar Jib-Crane

The Harnischfeger Corporation of Milwaukee, world's largest manufacturer of overhead traveling crane and hoist equipment, has recently developed a new self-supporting pillar jib-crane for work in side bays, low headroom areas, and other confined spaces where overhead traveling crane or hoist service is not available or practical. A strongly-built, well-balanced unit with jib-arm swinging on the finest roller bearings, this jib-crane is built in capacities up to 5 tons, heights up to 20 feet and to a maximum radius of 20 feet. It is practical for use

throughout industry—in machine shops, steel mills, wire mills, canneries—and all types of production plants where materials are lifted, lowered or moved in the process of manufacture. Several are already in use throughout the country. Among its typical uses is the work which is being handled by a recent installation of the 5-ton type for transferring plates from a modern welding shop to industrial trucks in a side bay too low for crane service. Another 2-ton type is typically used in a steel mill for service in moving the ladle from the side bay in an electric furnace operation.

This type of crane may be furnished with either the standard P&H pendant rope or push-button controls on the hoist and, for slightly higher cost, may be equipped with the newly-presented P&H Push-button Master Variable Speed Controller which controls all lifting, lowering and traveling operations. Operators report that the boom swings with ease and that it is a great aid in speeding up production. Installation is made without the need of any revamping of existing supports. Further information may be obtained by writing the Harnischfeger Corporation, 4497 W. National Avenue, Milwaukee, Wisconsin.

New Reeves Vari-Speed Motodrive

Reeves Pulley Co., Columbus, Ind., manufacturers of variable speed control equipment, announces a new type of automatic and remote control for use with the Reeves Vari-Speed Motodrive. The Reeves Motodrive

is a speed control unit combining a driving motor, variable speed mechanism and reduction gears (where required) in a self-contained unit. It is built in five sizes, 1/4 to 10 h.p. capacities, covering speed ratios from 2:1 through 6:1, in both horizontal and vertical designs.

The new control, known as Fluid Pressure Control, is available for all units of Motodrive. It can be used to automatically regulate speed from pressure variation as in stoker feed on a boiler, maintenance of constant fluid pressure in a pipe line or tank upon which there is variable demand, uniform tension between machine sections or between a machine and rewinder, and similar requirements for automatic speed control. It may also be used as a manual Remote Control or as a semi-automatic manual control in different ways.

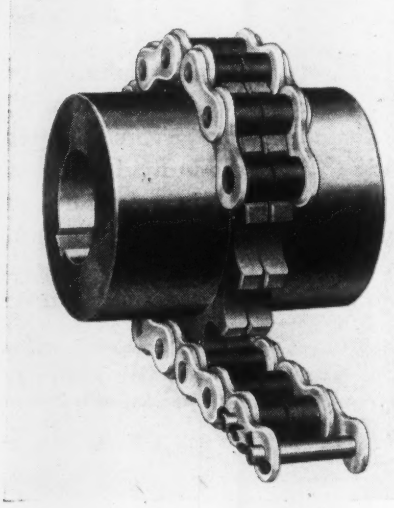
The complete control consists of a bellows shifting mechanism mounted on the Motodrive as shown in cut, an adjustable pressure reducing valve located where desired, auxiliary valves if needed, and connecting pipes. Fluid pressure is transmitted by means of oil, water, steam, gas or air by a valve through piping to the bellows shifting mechanism which operates to increase or decrease speed on the Motodrive and hence on the driven machine. As shown, the bellows shifting mechanism is very compact and is mounted on the Motodrive in place of regular manual handwheel control.

Speed of shifting depends on the kind of fluid used. Air is fastest, and will shift the control over the widest (6:1) ratio through its complete speed range in from two to four seconds. Speed changes are smooth and gradual over the entire range of the unit and desired speed settings are maintained accurately and positively as long as desired. While the control is very sensitive and is responsive to slight changes in pressure, the amount of pressure required varies with the size of Motodrive. On the largest unit it ranges from 5 pounds per square inch (to start shifting the Motodrive from minimum speed) to 30 pounds (to attain maximum speed). Pressure gauges may be used to indicate relative speed of the Motodrive.

New Link-Belt Flexible Coupling

Announcement is made by Link-Belt Co., Chicago, Philadelphia, Indianapolis, of the development of a new flexible coupling, Type "RCB," which embodies major improvements over the company's Type "RC" roller-chain coupling long furnished for connecting shafting in line.

The new "RCB" coupling consists of two cut tooth sprocket wheels (or coupling halves) which are connected by a piece of specially constructed single-width finished steel roller chain, using a recently-patented divided-roller feature which combines the advantage of double roller chain with the more rugged and simple construction of single width chain. The divided roller provides independent roller action for each sprocket, and as the contact between roller and sprocket causes the roller to revolve on its bushing, any tendency to scuff the rollers and sprocket teeth is said to be avoided. Longer coupling life, and extension of the range of efficient application, are claimed for the new coupling.



Other major improvements concern the grease-retaining housing or casing, which, when specified, is furnished for enclosure and automatic lubrication of the coupling. The most outstanding of these improvements is the use of two fittings, 180° apart, inside the

Continued on Page 18

Ljungstrom Air Preheaters
provide EASE of Inspection of EACH PART

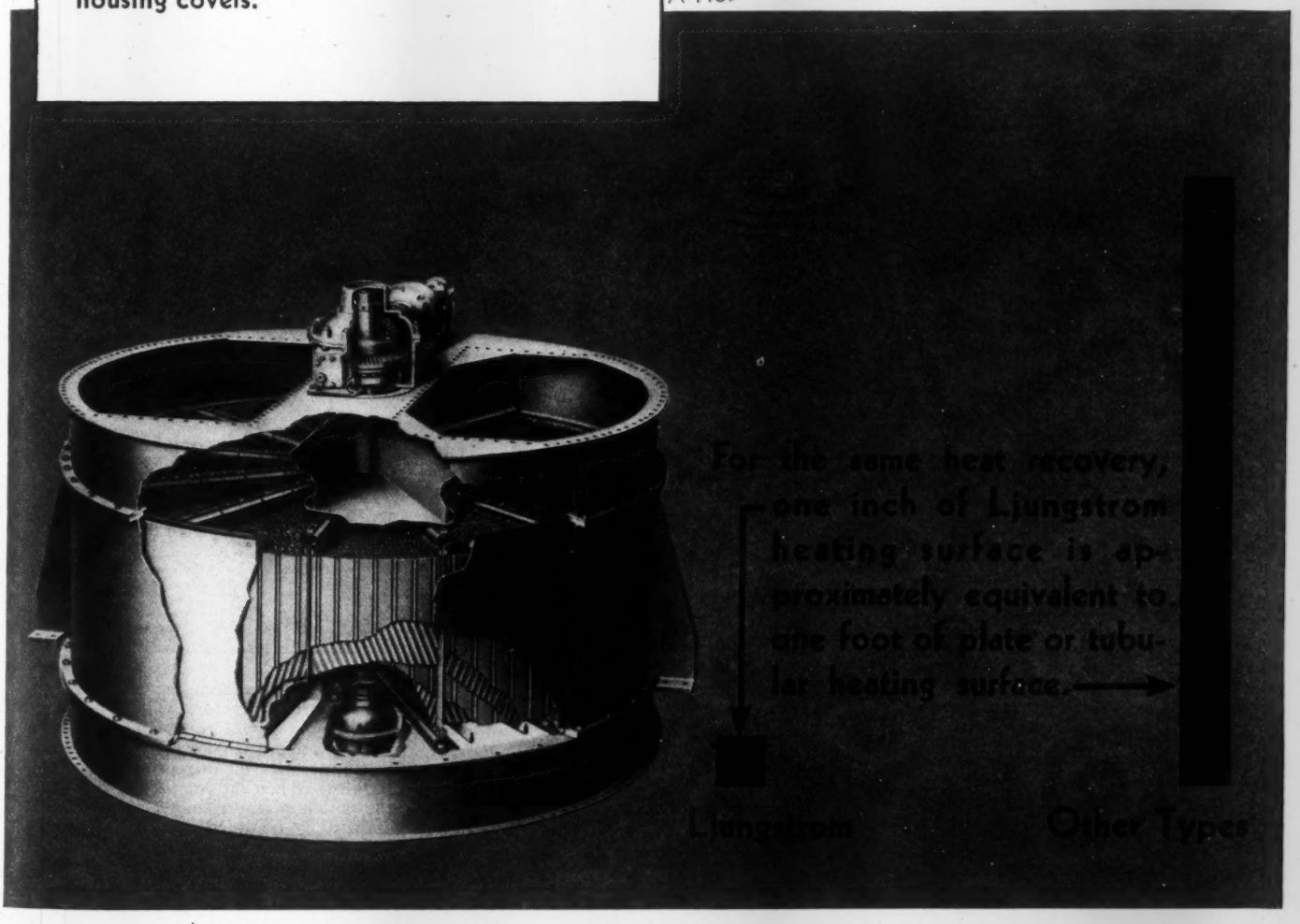
Every part of the Ljungstrom air preheater, which may require inspection, is readily accessible.

The motor, bearing housings and reduction gears are outside of the ducts, while the other parts are accessible through access doors or housing covers.

THE
AIR PREHEATER
CORPORATION

Under Management of THE SUPERHEATER CO.
60 East 42nd Street
New York, N. Y.

A-1169


For the same heat recovery, one inch of Ljungstrom heating surface is approximately equivalent to one foot of plate or tubular heating surface.
Ljungstrom
Other Types

Continued from page 16

housing, to permit packing the housing with grease, without necessity of dismantling. Another improvement consists of furnishing a better seal between the two halves, to avoid leakage of grease. To embody these changes, the size of housing has been increased slightly as compared with that furnished with the "RC" roller-chain coupling. A 1937 edition of illustrated Book No. 1545 gives dimensions, ratings and other data.

New B&W Coal Pulverizer

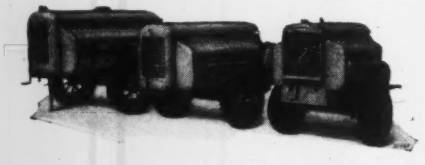
A new coal pulverizer characterized by low power consumption, high capacity for a given grinding-ring diameter, low maintenance, and quiet operation has been developed by The Babcock & Wilcox Company, 85 Liberty Street, New York, N. Y. It is known as the B&W Type E Pulverizer. It utilizes the well-known ball-bearing principle of pulverizing common to all B&W Type B Pulverizers and supplants the latter in a certain range of sizes.

High capacity for a given size and power consumption as low as 9 kw-hr. per ton of Pittsburgh seam coal pulverized to pass 65 per cent through 200 mesh result from outward radial flow of coal and improved classification of fines. Maintenance costs are low because of the use of improved ball material and increased capacity. Smooth, quiet operation results from isolation of the grinding elements from the housing, short main shaft and heavy construction, and its moderate speed.

The coal is pulverized by a single row of large-size balls between a stationary top ring and a rotating bottom ring driven from the base of the mill. Raw coal is fed to the inside of the upper grinding ring and, aided by centrifugal force, passes outward between the grinding balls. Preheated air passing upward between the grinding elements and the housing picks up the ground coal-particles, drying them as it carries them to a rotating classifier in the top of the pulverizer whence oversize particles are returned to the grinding zone for further reduction. Fineness of the coal delivered is regulated by the air flow through the mill. Capacities of the sizes now designed are from 2.0 to 13 tons per hour.

New Light-Weight Portable Compressors

Three new light-weight models in the Ingersoll-Rand line of air-cooled portable compressors have recently been announced by that company. The smallest of these, the model 55, delivers 55 cu. ft. of air per minute at 80 pounds pressure; enough to operate a JA-30 Jackhamer, a dry JA-45 Jackhamer at 62 pounds or a CC-45 Paving Breaker.



The next larger, the Model 85A, delivers 85 cu. ft. of air per minute at 100 pounds pressure; sufficient for operation of a JA-45 or a dry JA-55 Jackhamer or two CC-45 Paving Breakers. The largest of the three new models, the 105-A, is rated at 105 cu. ft. of air per minute at 100 pounds pressure and will operate the largest dry Jackhamer or three paving breakers.

These three newly styled light-weight mountings are designed for balance of weight and rigid construction throughout, permitting towing at speeds up to 35 miles per hour. Leaf-type spring mountings carry the machine on the running gear. Timken roller-bearing wheels are furnished with either pneumatic or solid rubber tires. Covers are hinged in the manner conventional for the engine hood of an automobile. Tool boxes built into the mounting provide a means of carrying "Jackhamers" and other tools. Air receiver and fuel tank are built end to end in the models 85A and 105-A for greater compactness and accessibility.

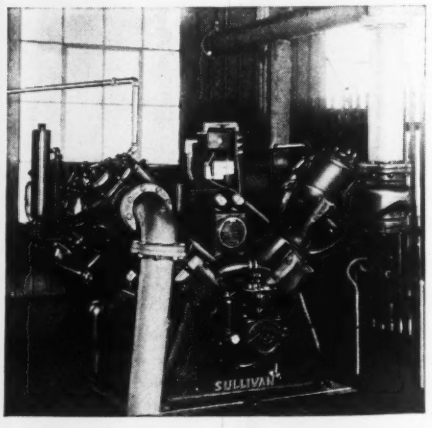
Models 85A and 105-A incorporate the famous I-R two-stage, air-cooled compressor and are furnished with either gasoline or oil engine. The Model 55 compressor (3 cylinder) is single-stage, air-cooled and driven by a gasoline engine.

Detailed information on these as well as other models that comprise the complete line of portable compressor sizes from 55 to 420 cu. ft. per min. is contained in bulletin 3264, copies of which are available from Ingersoll-Rand Company, 11 Broadway, New York, N. Y., or any of their branch offices.

Sullivan Air and Gas Compressors

One of the most interesting new applications just announced by Sullivan Machinery Co., 912 Woodland Ave., Michigan City, Ind., of the modern Sullivan WN-112 Air and Gas Compressor is the installation illustrated herewith.

For this application, where the maximum output of the compressor is required intermittently and the continuous demand is light, Sullivan engineers devised an interesting selective electrical regulation which automatically controls the compressor and its air output in the most economical manner. This control responds to the rate of air usage, "sampling" taking place each time the compressor unloads.



When the maximum capacity is required, the compressor motor, which is a built-in synchronous type, runs continuously and the compressor is "loaded" or "unloaded" to maintain the air pressure between 98 and 100 lbs. When the compressor unloads and the sampling feature indicates that the rate of air usage is low, the motor stops and the unit does not start again until the air pressure drops a pre-determined amount—usually 10 lbs.

Continued on Page 20

Complete Flexibility
Leakproof Service
Low Maintenance

BARCO FLEXIBLE JOINTS

Wherever pipe movement is involved BARCO flexibility, leak-proof construction and longer life guarantee the savings and profits of uninterrupted production. BARCO flexible ball joints are provided with two separate and distinct non-metallic, fluid-tight seats, and are indispensable on any assembly of steam, air, or fluid-carrying pipe which is subject to movement, expansion, or vibration. Experienced engineers specify and use BARCO. Experienced operators always have them on hand in the storehouse.

BARCO MANUFACTURING CO.
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Catalog 206 will give you the complete details.

A Versatile New Material

—Transparent Bakelite Molded!

Typical uses for Transparent Bakelite Molded are in refrigerator door handles, automatic pencils, ruby lenses, and housing covers.

HERE is a new plastic material that offers unlimited possibilities to manufacturers and designers! Clear, colorful and highly durable—Transparent Bakelite Molded adds visibility to the other well-known advantages of Bakelite Molded. It is available in a range of enduring colors.

For decorative service parts or products—such as handles, knobs, or containers—this new material provides gem-like beauty in readily moldable form. For tail-light lenses, housings, "windows" on machinery and equipment, and other uses where light transmission is important, it furnishes visibility and sturdiness.

Various properties of Transparent Bakelite Molded are comparable to those of General Purpose Bakelite Molded. It is less hygroscopic; and its tensile, impact and flexing strengths are high. It withstands temperatures of 250°F. Its dielectric properties, permanence of form, and chemical stability are excellent.

Write for complete information on this useful new material.

BAKELITE CORPORATION, 247 PARK AVENUE, NEW YORK, N.Y.

BAKELITE CORPORATION OF CANADA, LIMITED, 163 Dufferin Street, Toronto, Canada *West Coast:* Electrical Specialty Co., Inc., Los Angeles and San Francisco, Cal.

BAKELITE

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RATE Announcements under this heading in MECHANICAL ENGINEERING are inserted at the flat rate of $1.25 a line per issue, $1.00 a line to A.S.M.E. members. Minimum charge, three line basis. Uniform style set-up. Copy must be in hand not later than the 10th of the month preceding date of publication.

• Keep Informed . . .

Continued from page 18

The adjustable pressure differential holds the desired terminal pressure to close limits during peak periods and allows the motor to shut down for a reasonable period when the need for air is light.

Within a Turbine

Steam enters a turbine at a temperature hot enough to set fire to a piece of wood and .03 of a second later leaves it at a temperature too cool for a comfortable bath. It may enter at a pressure of 1200 pounds per square inch and leave at the low vacuum of one-thirtieth of an atmosphere. The peripheral speed of recent large turbine rotors is approximately 820 miles per hour—80 miles faster than the speed of sound. These interesting facts were pointed out by W. E. Blowney of the General Electric Turbine Engineering Department in a paper presented recently to the Mid-West Power Conference at Chicago.

In 1903, the largest turbine generator in service was a 5000-kilowatt machine installed at Chicago. It was ten times larger than any previous unit. Today, the largest machine in service, also at Chicago, is 42 times the size of that 1903 "colossal," Mr. Blowney declared.

The initial steam temperature in turbines has reached the 950 deg range; further progress to higher temperatures is limited until low creep materials are available. The study of creep, which is the permanent deformation of metal under stress while hot, is being intensively investigated, he said.

• BUSINESS CHANGES

Norma-Hoffmann Promotions

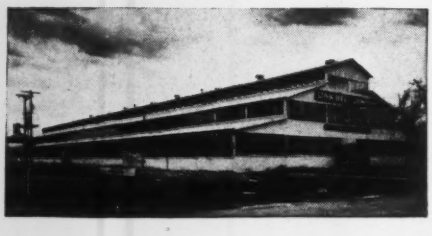
Norma-Hoffmann Bearings Corp., Stamford, Conn., announces the appointment of D. E. Batesole, formerly assistant chief engineer, as chief engineer succeeding the late Geo. R. Bott. T. E. Rounds of the Engineering Department has been made assistant chief engineer.

G. E. Officers Re-elected

New York, Apr. 22—At the meeting of the board of directors of the General Electric Company today, Owen D. Young was re-elected chairman of the board and Gerard Swope president of the company. All other officers of the company were also re-elected.

Link-Belt Atlanta Plant Enlarged

Harold L. Hoefman, general manager of the Atlanta plant of Link-Belt Company, located at 1116 Murphy Avenue, S. W.,



announces that this plant has in recent months been substantially enlarged in order to provide for a larger engineering department, more shipping space, and additional area for stocks of elevating, conveying and power transmitting machinery equipment.

In the main, this latest improvement consists of a 20-ft. wide × 288-ft. long extension to the north side of the building, as shown in foreground of the accompanying illustration. The construction throughout consists of structural steel framing with steel sash and corrugated metal covering.

Sullivan Machinery Company Moves

The Sullivan Machinery Company, makers of Air and Gas Compressors, Core Drills, Oil Field Drills, Oil Well Pumps, Rock Drills, Hoists and Coal Mining Machinery is moving their general offices from 307 North Michigan Avenue, Chicago, Illinois, to Michigan City, Indiana.

The Chicago Sales Office will remain at the Chicago address. The company operates plants in Michigan City, Indiana and Claremont, New Hampshire, with additional manufacturing facilities in Dundas, Ontario Canada and Grantham, England.

• LATEST CATALOGS

New Bakelite Acetate Plastics

After several years of extensive research, Bakelite Corporation, 247 Park Ave., New York, N. Y., announces the development of a line of high quality acetate molding materials. Bakelite acetates are thermoplastic molding compounds with a cellulose acetate base and are recommended for both injection and compression molding. They are manufactured in granular form in a wide range of colors, including crystal clear, black and variegated mottles. They are also available in transparent, translucent and opaque colors.

Bakelite acetates are custom-made materials and, therefore, molding properties and finished material properties can be altered to suit specific applications. Molded pieces produced from Bakelite acetates have a lustrous finish. They are warm and pleasing to the touch. These molded parts have unusual strength properties, being especially resistant to impact. Bakelite acetate materials are suitable for an infinite variety of uses, restricted only by the effect of heat and certain solvents.

6 Minutes with 6 Metals

The pages of a new 16 page booklet entitled "6 Minutes-With 6 Metals" include the characteristics and uses of the special alloys such as Inconel, "K", "S", and "R" Monel as well as the more generally known Monel and nickel. Copies may be obtained from The International Nickel Company, Inc., 67 Wall Street, New York, N. Y.

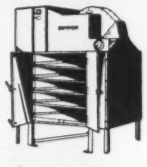
Norma-Hoffmann Precision Needle Roller Bearings and Needle Rollers

Above is the title of a new Bulletin No. 962 just issued by Norma-Hoffmann Bearings Corp., Stamford, Conn. The bearings described therein were originally developed for wrist pin applications in internal combustion engines of the Diesel type, where the motion is oscillating, the load heavy, space restricted, and lubrication difficult. Their success under these conditions has led to the use of Precision Needle Roller Bearings for many other difficult duties:—cam rollers, planetary reduction gears, valve rocker shafts, pump shafts, idler gears—in internal combustion engines and machine tools. In general, they commend themselves for ap-

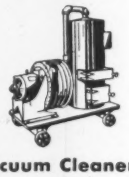
Continued on Page 22

TO CONTROL DYE DUST

at General Aniline Works



Drying Equipment



Vacuum Cleaners

Blowers . . . Exhausters

STURTEVANT AIR WASHERS serve a double purpose at the well known General Aniline Works, Inc., Rensselaer, New York.

Fine dye dust must be removed from the air *inside* for the protection and comfort of employees . . . must be prevented from escaping to the *outside* and contaminating the neighborhood.

Plant air is circulated through the Sturtevent Air Washers, where *all* solid matter is removed. Air is then returned to the rooms in a purified, freshened condition.

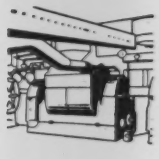
If you have a similar problem, or any other air handling and conditioning problems . . . take advantage of Sturtevant's 75 years of air engineering experience.

General Aniline System designed and installed by

COOLING & AIR CONDITIONING DIVISION

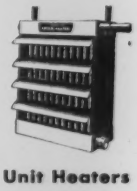
B. F. STURTEVANT CO., Hyde Park, BOSTON, MASS.

Branch Offices in 40 Other Cities B. F. Sturtevant Co. of Canada, Ltd. — Galt, Toronto, Montreal



Air Conditioning

Draft Equipment



Unit Heaters

WORLD'S LARGEST MAKER OF AIR HANDLING AND CONDITIONING EQUIPMENT

Continued from page 20

plications where minimum weight, low friction, and highly concentrated load capacity are requisites. The new Bulletin gives complete data as to sizes, dimensions, and load ratings of complete bearings. Standard sizes of Precision Needle Rollers are also given, together with engineering information for those who may wish to manufacture their own raceways. A page of drawings of typical applications completes the book.

Avioflex—A New Type Hose

The Chicago Metal Hose Corp., 1305 S. Third Ave., Maywood, Ill., announces a new type hose "Avioflex" for oil connections that utilizes a multiple cellulose sheet seal over flexible metal which provides permanent resistance to action of oil at any operating temperature. It has unlimited flexing life and is now adapted to machine tool and other industrial uses. This latest bulletin describes both Avioflex Hose and Avio-Tite Couplings.

A-C Centrifugal Pumps

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has come out with a new 50 page well illustrated general centrifugal pump bulletin No. 1651-A covering all types of their manufacture. It not only shows many new and interesting installations of pumps for general service but also for city water works, mine pumping, sewage pumping and recent new designs for high pressure, high efficiency boiler feed pumping.

Fabrication of USS Stainless Steels

A 64-page booklet, attractively printed in two colors, entitled "The Fabrication of USS Stainless Steels, Part I," has just been issued by the United States Steel Corporation Subsidiaries. Copies may be obtained from the nearest Carnegie-Illinois district office.

The new book describes in detail the welding, riveting and soldering techniques applicable to all the various grades of USS Stainless Steels. An introduction deals with the three principal classifications of stainless steels, namely, the austenitic, ferritic and martensitic steels. It is pointed out that the austenitic USS Stainless Steels are iron-chromium-nickel alloys, normally non-magnetic, hardenable by cold working but not by quenching, tougher and more ductile in the annealed condition than ordinary steels; and include USS 18-8, USS 18-8 Mo., USS 18-8 Ti, USS 18-8 Cb., USS 19-9, USS 25-12, USS 25-20.

Similarly, the ferritic stainless steels, including USS 17, USS 21 and USS 27, are discussed as magnetic steels, essentially ferritic at all times, only slightly hardened by quenching or cold working, with relatively high strength, ductile when properly annealed. Martensitic stainless steels such as USS 12 are also iron-chromium alloys, magnetic, ferritic in the annealed condition, hardenable by quenching, with excellent physical properties of strength and toughness.

Each of these types of steels is analyzed with reference to fabrication procedure. Fusion welding, including metal arc welding, acetylene and atomic hydrogen welding, and the welding of stainless to carbon steels are described as applied to austenitic, ferritic and martensitic USS Stainless Steels successively. Annealing and heat treatment of these steels, primarily as a method of relieving stresses developed in welding, are subjects fully treated.

The finishing of welds on stainless steels, including grinding and polishing, as well as the removal of scale by sandblasting, pickling and passivation, are briefly described. Formulae for pickling solutions, and directions for building pickling and passivation tank, and similar useful data are helpful features for stainless steel fabricators.

Concluding the section on welding USS Stainless Steels are pages on the resistance welding of stainless, particularly austenitic steels. Flash, spot, projection and seam welding, together with the latest electrical and mechanical controls, present new opportunities for high-speed, profitable fabrication.

Among the topics developed under the heading of the riveting of USS Stainless Steels are the preparation of plates for riveting, typical shop procedure including driving temperatures for austenitic, ferritic and martensitic steels, and caulking. Likewise both soft and hard or silver soldering techniques are explained, with recommendations as to installations best suited for welding, riveting or soldering, or combinations of these joining methods.

A final feature of the book portrays over thirty types of joints and contains suggestions as to joint design for the wide range of products which are now fabricated from USS Stainless Steels.

New Treatise on Boiler Water Conditioning

The Elgin Softener Corporation has published a new edition of a treatise on boiler water entitled "The Inside Story of Boiler Water Conditioning." The purpose of the treatise, according to the manufacturer, is to explain in simple non-technical terms the conditions most frequently encountered and to discuss the various methods of softening, treating water and removing concentrations from the boiler. A copy may be obtained by writing the Elgin Softener Corporation, Elgin, Illinois.

James Speed Reducers

D. O. James Mfg. Co., 1120 West Monroe St., Chicago, Ill., has just published a new 176 page Speed Reducer Catalog #150, with very complete listings of the following types of Reducers: Herringbone, Worm, Helical Worm, Double Worm, Spiral Bevel, Spiral Bevel Herringbone, Spiral Bevel Spur, Spur Gear, also Flexible Couplings. This book shows the stock ratios assembled from stock parts for immediate shipment.

Bristol's Potentiometers

All of the Pyromaster Round-Chart Potentiometers now manufactured by The Bristol Company, 21 Bridge St., Waterbury, Conn., are described in a new bulletin available through the Main Office of this company in Waterbury, Conn., and branch offices in various cities throughout the country.

This new publication describes and explains the simple operating characteristics of Bristol's Pyromaster adapted to: Pyrometers, Reset Free-Vane Pneumatic Temperature Controllers, Ampliset Free-Vane Pneumatic Temperature Controllers, Unitact Electric Temperature Controllers, Tachometers, Resistance Thermometers, and Millivoltmeters. A copy of Bulletin No. 507 may be obtained upon request.

New Stress-Rupture Test Data

The value of the recently developed stress-rupture test in determining the high temperature characteristics of various steels is discussed in considerable detail in Technical Bulletin No. 21, just issued by The Steel and Tube Division of The Timken Roller Bearing Company. This bulletin, which is an authorized reprint of a paper presented by A. E. White and C. L. Clark of the Department of Engineering Research of the University of Michigan and W. G. Hildorf, Chief Metallurgist of The Timken Roller Bearing Company, is a 16 page $8\frac{1}{2} \times 11''$ bulletin, punched for filing in a standard three-ring binder. For diagrams, three tables and six photomicrographs substantiate the discussion, which points out the practical and technical value of this test and its data to anyone interested in the design, operation or maintenance, or metallurgy connected with high temperature operations in oil refining, steam generation or similar processes. Copies of this new bulletin are available on request to The Steel and Tube Division of The Timken Roller Bearing Company, Canton, Ohio.

Bakelite Plastics

A new edition of the booklet "The Versatile Service of Bakelite Plastics" has just been published by Bakelite Corporation, 247 Park Ave., New York, N. Y. This sixteen-page booklet tells the history of modern plastics from the time of their discovery by Dr. L. H. Baekeland up to the present day, when they are being used by practically every industry in one form or another. The booklet points out that few people have failed to hear of plastics, but many know only of some special application—perhaps a cigarette holder, the modern handset telephone, an automobile timing gear or a radio cabinet. The story of Bakelite plastics—what they are and how they are used—is told in concise, entertaining style. Copies of this booklet may be had upon request.

COMING MEETINGS AND EXPOSITIONS

For the next three months

June	
2–3	American Management Association, Annual Meeting, Hotel New Yorker, New York City
12–17	Society of Automotive Engineers, Summer Meeting, The Greenbrier, White Sulphur Springs, W. Va.
19	National Aeronautical Association, 2nd Annual Santa Ana, Calif., Air Show.
20–24	American Institute of Electrical Engineers, Annual Summer Convention, Washington, D. C.
20–22	American Society of Heating & Ventilating Engineers, Semi-Annual Meeting, The Homestead, Hot Springs, Va.
20–24	American Society of Refrigerating Engineers, Spring Meeting, State College, Pa.
Wk. of 20	American Society of Mechanical Engineers, Semi-Annual Meeting, St. Louis, Mo.
27–30	Society for the Promotion of Engineering Education, Annual Meeting, A. & M. College of Texas, College Station, Texas.
27–July 1	American Association for the Advancement of Science, Summer Meeting, Ottawa, Canada.
27–July 1	American Society for Testing Materials, Annual Meeting, Atlantic City, N. J.
29–30	Institute of the Aeronautical Sciences, Inc., Technical Meeting, Ottawa, Canada.
JULY	
6–9	National Aeronautical Association, 11th National Championship Model Airplane Contest, Detroit, Michigan.
AUGUST	
9–12	American Institute of Electrical Engineers, Annual Pacific Coast Convention, Portland, Oregon
29–Sept. 7	National Aeronautic Association, 3rd Annual Midwest Soaring Contest, Frankfort, Mich.

This illustration is only used to vispalize an idea. It is not intended to apply specifically to manufacturers of tractors, who are using more and more forgings to effectively lessen deadwei

GET RID OF USELESS DEAD WEIGHT

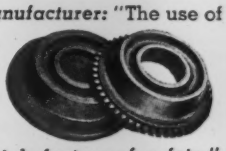
Design it out with FORGINGS

In these days, equipment loaded down with power-wasting, fuel-consuming deadweight is definitely handicapped. This deadweight handicap can be overcome in all types of modern equipment by replacing heavy, bulky parts with plus-strength forgings. In the reduction of deadweight, structural strength and parts' durability is also enhanced when forgings are used. Forging compacts the grain structure of the metal . . . kneads the steel fibers into a dense mass of hoarded strength . . . produces parts that afford the widest possible margin of resistance to wear, impact shock, and metal fatigue. Forgings also reduce machining costs appreciably. These advantages should incline design engineers to specify more forgings as a product improvement measure. A competent forging engineer will be glad to counsel with you.

"Drop Forging Topics" is issued monthly, and sent free upon request. Send your name and address if you are not now receiving it, and copies will be mailed regularly.

Says Pump Manufacturer: "Our primary object in using five to six hundred forgings in Worthington power and steam pumps, is to be assured of parts that are 'break-proof,' light in weight, and economical to machine."

Says Hoist Manufacturer: "The use of forgings is mandatory if we are to obtain light weight with high factors of safety."



★ ★ ★

Forgings contribute greatly to public safety and welfare. Their durable strength has done much to make automobiles, buses, trains, airplanes and other transportation vehicles economical to operate and safer to run.

THERE ARE NO SUBSTITUTES FOR FORGINGS

DROP FORGING ASSOCIATION

605 HANNA BUILDING · CLEVELAND, OHIO

SYMBOLIC EMBLEM OF THE DROP FORGING ASSOCIATION